2005

Improving enterprise business processes with systems analysis and design methodologies and tools.

Anas Radwan Kazaal
University of Windsor

IMPROVING ENTERPRISE BUSINESS PROCESSES WITH SYSTEMS ANALYSIS AND DESIGN METHODOLOGIES AND TOOLS

by

Anas Radwan Kazaal

A Thesis
Submitted to the Faculty of Graduate Studies and Research
through Industrial and Manufacturing Systems Engineering
in Partial Fulfillment of the Requirements for
the Degree of Master of Applied Science at the
University of Windsor

Windsor, Ontario, Canada

2005

Your file Votre référence
ISBN: 0-494-09788-4
Our file Notre référence
ISBN: 0-494-09788-4

1027817

ABSTRACT

Enterprises have to be organized in a business process oriented way. This is in order to be successful in a changing and challenging business environment including uncertainty and complexity in managing business and manufacturing processes.

The main objective of this thesis is to implement comprehensive modelling methodologies and tools that capture all useful information included within the enterprise business processes. This has been achieved first through implementing the Systems Analysis and Design (SAD) methodologies and tools for integrating the business design processes.

The implementation should recognize the enterprise organization view, data and information view, function view, and also product/ service view. Such recognition is required in order to improve the reuse of business process models for the implementation of workflow management applications.

The implemented design methodologies have been demonstrated through two case studies, including the modelling of business and automotive manufacturing processes.

A structured representation of the functions and activities within the modeled business processes has been presented. That included the business processes inputs, outputs, mechanisms and control ($IDEF_0$) using an innovated tool namely “AI0WIN07”. ADONIS Business Process Management toolkit and associated components have been used in this thesis. Its purpose is to analyze and redesign interactions between the modeled business internal processes and their end users, represented through the Line of Visibility Enterprise Modelling (LOVEM) in ADONIS.

In Addition, the Architecture of the Integrated Information System (ARIS) has been presented in both implementations using ARIS tool set. The ARIS implementation has assisted in supporting analysis for potential changes, specifying requirements, and also supporting the modeled business processes systems level design and integration activities.

Results of using the selected graphical design languages with the systematic explanations of modelling the business process functions and activities revealed the need for implementing comprehensive SAD methodologies. Also, the SAD methodologies have assisted with integrating the enterprise through modelling its business activities, technology, and human elements involved.

The benefits and disadvantages of each modelling methodology and tool is studied and discussed in detail in this thesis.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor Dr. Waguih ElMaraghy for all his help, assistance, and support he continuously provided me to accomplish this work. It is very important for me to mention that the match of both of our research interests and motivations has played a major role to help me achieve my academic research outputs.

I would like to also recognize my other committee members, Dr. Guoqing Zhang and Dr. Fazle Baki, for their distinguished comments, valuable suggestions, and for their review of this work.

I want to thank all my colleagues in the Intelligent Manufacturing System (IMS) Centre, where I have received all support and assistance from them to accomplish this work.

Special thanks filled with gratefulness and gratitude to my father and my mother, the ones who never hesitated to provide me with any support to help me achieve my desired academic goals. Special thanks to my brothers and sisters who were very supportive towards helping me to accomplish this work.

A final thought that I believe I do owe to mention by thanking the ones who are teaching me that knowledge is the key toward success. Their continuous assistance and inspirations have helped me a lot in all aspects of my life by being determined, wise, sincere, and systematic for future decision-making.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMENCLATURE

ABC	Activity Based Costing
ADL	Adonis Definition Language
ARC	Academic Requirements Committee
ARIS	Architecture Of Integrated Information System
BI	Business Innovation
BPI	Business Process Improvement
BPM	Business Process Modelling
BPM*	Business Process Management
BPMA	Business Process Mapping And Analysis
BPR	Business Processes Reengineering
CAA	Computer Aided Analysis
CDRS	Crash Data Retrieval System
CEAB	Canadian Engineering Accreditation Board
CEP	Confirmatory Examination Program
CEQB	Canadian Engineering Qualification Board
CIM	Computer Integrated Manufacturing
CIMOSA	Computer Integrated Manufacturing Open System Architecture
CIS	CIMOSA Integrating Infrastructure
CMP	Critical Measurement Points
CPI	Continuous Process Improvement
CSF	Critical Success Factors
EDPC	Event Driven Process Chain
EIT	Engineering Intern Training
ERC	Experience Requirements Committee
FEA	Functional Economic Analysis
FIPS 183	Federal Information Processing Standards 183
GSP	Goal Strategy Policy
IS	Information Systems
IT	Information Technology

JLOVC	Job Line Of Visibility Charts
LLOVC	Logical Line Of Visibility Charts
LOVEM	Line Of Visibility Enterprise Modelling
LVC	Line Of Visibility Charts
MLC	Modelling Life Cycle
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
OOM	Object Oriented Methods
PA	Problem Areas
PEO	Professional Engineers Ontario
PLOVC	Physical Line Of Visibility Chart
PPE	Professional Practice Examination
R.R.O	R.R.O 1990
R.S.O	R.S.O 1990
ROI	Return On Investment
SAD	Systems Analysis And Design
SQL	Structured Query Language
UML	Unified Modelling Language
WFM	Work Flow Management
XML	Extensible Markup Language
ABC	Activity Based Costing
ADL	Adonis Definition Language

CHAPTER 1

INTRODUCTION

1.1 Introduction

An enterprise can be analyzed and integrated through its business processes. Business Process Modelling (BPM) provides a comprehensive understanding of the process's inputs, outputs, mechanisms, and controls. Since the aptness of modelling methodologies is very much dependent on the purpose of modelling, systems designers and developers have introduced different processes modelling approaches.

Some modelling efforts might be primarily descriptive by nature while in other cases an optimized implementation solution is sought where process analysts have to be supported by formal evaluation tools. This requires easy and clear processes description, which is far too detailed for merely descriptive purposes. Using the right model involves taking into account the purpose of the analysis and knowledge of the available process modelling methodologies and tools. It traditionally focused on supporting the modelling of business processes, with the aim of enabling faster and more cost-effective process executions.

As business processes become more complex, there is a desire for capturing the business process requirements by getting more visibility into process management to quickly spot problems and areas for improvements. That requires the ability to assess and manage the enterprise business processes by selecting the right comprehensive methodologies and tools. Moreover, it is possible to take actions to improve and optimize process execution by better capturing its requirements. Such action will assist to design business processes that have higher quality and lower costs.

The main goals of this thesis are to review System Analysis and Design (SAD) methodologies literature focusing on graphical BPM languages and tools implemented in the industry. That will be followed by implementing BPM methodologies for integrating and improving the enterprise, managing integration difficulties and developing technology solutions. Appropriate tools to improve the business processes performance and achieve reduction in time and efforts of the enterprise systems development will support such implementations.

1.2 Research Focus

The aim of this thesis research work is to represent and model enterprise business/ automotive manufacturing processes by implementing integrated SAD Methodologies. That will be supported with BPM tools with a structured and logical design strategy for the desire of developing new integrated solutions of the engineering and business problems. Three main comprehensive design methodologies have been selected including $IDEF_0$, Line of Visibility Enterprise Modelling (LOVEM) as well as the Architecture of the Integrated Information System (ARIS) processes modelling approach.

1.3 Research Motivation

There is a need to focus on comprehensive modelling methodologies for the development, management, and improvement of the enterprise business processes. It is obvious that the operational complexities can be considered as a major barrier to a good processes management and enterprise improvement. Most work done by researchers has covered only one type design methodology for modelling functional relationships and data or information flow. There is a need to conduct research investigations through using of different SAD methodologies focusing on the enterprise business workflow management. Such implementation will be achieved through selecting optimal tools that help in capturing all business/ manufacturing processes requirements to successfully execute desired outputs.

1.4 Problem Statement

The SAD modelling methodologies and tools provide users with information about why the quality of a process execution is low. Also, what will be the outcome of a certain process, or how many processes will be started on certain time? This information is crucial to gain visibility into the processes, and quickly identify solutions.

Traditional design methodologies have focused on the simple flow charts types' problems. The objective of this work is to convert the business process flow charts to a comprehensive graphical representation with integrated set of graphical modelling methodologies. That will assist in capturing, analyzing and redesigning interactions between customers and business internal processes. That will be achieved through recognizing the organization view, data view, function view and also product/ service view. The recognition of the four views will lead to improve reusing of the business process models for the implementation of workflow management applications.

The thesis research work can be stated as: "Organizing and Documenting Enterprise Business Processes' Through Selected Comprehensive Design Methodologies Termed $IDEF_0$, LOVEM, and ARIS Can Replace Traditional Business Processes Flow Charting, Improve Enterprise Business Processes Performance, Manage Integration Difficulties, and Reduce Time and Efforts of Enterprise Systems Development and Reengineering".

1.5 Research Approach

A business process model can provide a comprehensive understanding of a process. Also, the enterprise can be analysed and integrated through its business processes. It should be emphasized the importance of correctly modelling the enterprise business processes by using the right model methodologies and tools. This requires taking into account the purpose of the analysis together with process modelling methodologies and tools.

The research initially started by conducting BPM literature review. Its aim is to describe the main process modelling methodologies and tools. That will include whether they have been designed on a theoretical or practical (Industry Modelling Based Methodologies) abstract. Such review will assist to classify business BPM methodologies according to their purpose, fields of applications, design methodology/ approach, framework type, architecture fields of applications and also solution technique type.

The results of such modelling approaches classifications' will guide to establish a basis for relating certain type of methodology to specific surveyed systems design publications with implemented/ developed tools.

Such basis will assist in extending the BPM research for selecting and using comprehensive modelling languages. That will provide a detailed description for the business processes' inputs, outputs, mechanisms, and controls. That will assist in analysing and redesigning interactions between customers and the internal processes. Such objective will be achieved through recognizing the organization view, data view, function view, and also product/ service view.

1.6 Business Improvement Vs. Reengineering

Identifying areas of improvement and better understanding of the business are the most declared purposes of business modelling. One approach for changing of a business is the Business Process Improvement (BPI). The other approach is Business Innovation (BI) and the Business Process Reengineering (BPR) can be considered as a sub BI as illustrated in Figure 1.1 and 1.2 below [Noran, 2004; Tétard, 2004; Fitzgerald, 2002; Nye, 1997] .

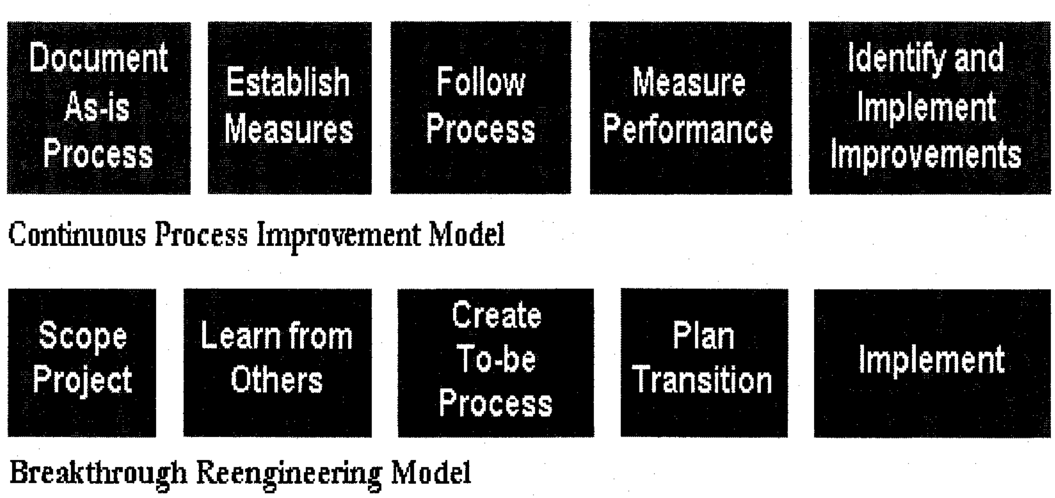


Figure 1.1: Business Improvement Vs. Reengineering [Tétard, 2004]

Both approaches can be compared based on the process, depth of change and the implications of such concepts. The BPI approach is considered to be incremental change based on the business model. Changes are applied in small continuous steps for the sake of minimizing any possible negative impact on the business.

The BI approach is considered to be more radical where both business processes as well model are considerably changed. Substantial improvement might be achieved but also implies a higher risk of failure [Underdown, 1997].

Process reengineering is the fundamental rethinking and redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed [Hammer, 1990; Hammer and Champy, 1993; Ould, 1995] .

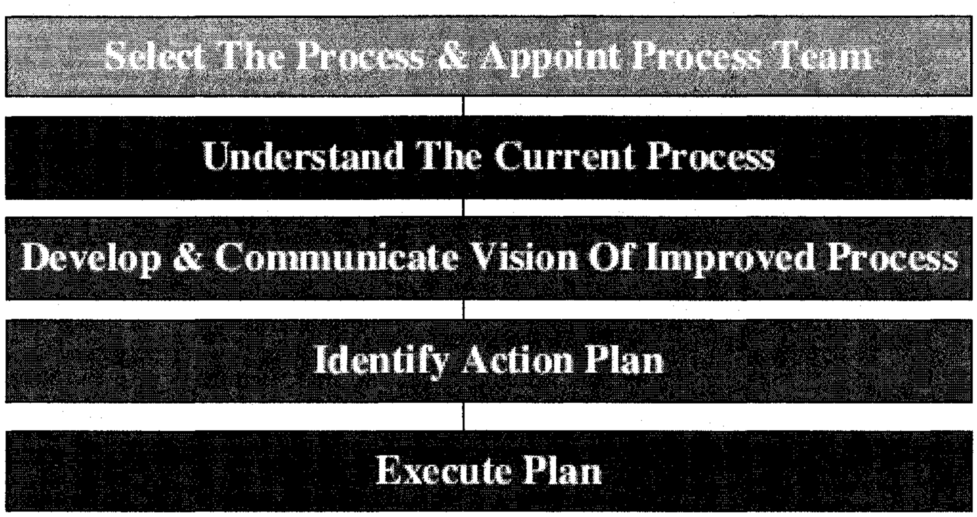


Figure 1.2: Key Steps of Implementing a BPR Strategy [Fitzgerald, 2002]

Considering all aspects of the existing business, BPR implies a high risk and also a task difficulty. The BPR may encounter strong resistance from human resources and even fail because of the mentioned reason.

It is believed that Information Systems (IS) are a key element in any business process approach being implemented. It can assist in minimize the risk of re-engineering failure. For successfully supporting the improvement/ innovation processes, IS must reflect and sustain the predicted business model or it will not be a motivated for change but yet another impediment against it.

1.7 Important Terms

1.7.1 Business Process And Business Process Management

Processes are relationships between inputs and outputs, where inputs are transformed into outputs using a series of activities, which add value to the inputs [Davenport, 1993].

Business process can be defined as the transformation of inputs such as raw material, information, or knowledge into outputs and results. Such transformations occur according the process guidance including policies, standards, procedures, rules and also individual knowledge. That will include available resources such as facilities, equipment, technologies, and also people [Burlton, 2001].

The business process content might include logical or illogical steps that cross professional functions and organization units. There are some performance indicators that are considered as measurable objectives since performance can be evaluated on an ongoing basis on outcomes. More and more, ensuring process completeness can help to understand whether the process delivers a clear product or service to an external stakeholder or another internal process.

According to Ould [1995] and Biemans et al. [2001], "Business Process" denotes the ensemble of activities that realize a company's objectives. Examples of such activities include the processing of insurance claims, the issuance of payments, the purchasing of supplies. That might also include people, computer systems, machines, or combinations thereof perform business processes.

A business process is the combination of a set of activities within an enterprise with a structure describing their logical order and dependence whose objective is to produce a desired result. According to Davenport [1993], business processes are defined as ''structured measured sets of activities designed to produce a specified output for a particular customer or market''.

A business process is related to enterprises, and it defines the way in which the goals of the enterprise are achieved. Also, it is a subset of the set of enterprise activities executed to realise a given objective of an enterprise or a part of an enterprise. That will lead to achieve some desired end-result of an enterprise to achieve some desired end-result [Saven, 2004].

There are two classifications of business processes. That includes "core" and "supportive" business processes. A core process is initiated from outside an organisation, for instance, chain of activities, which realize delivery of a product or service to a customer. Creating conditions for the primary process to be carried is described a secondary process. It is classified into two main processes. Management processes are first which control the organisation's overall strategies and objectives. Support processes are second, they support the core processes by offering sufficient resources [Saven, 2004].

Business Process Architecting (BPA) involves the definition of business processes in terms of their input and output. It involves assessment of business processes in terms of reliability, efficiency, and efficacy. In practice, business processes are seldom designed from scratch. Typically, existing business processes are taken as a starting point and adapted to changed requirements.

According to Burlton [2001], Business Process Management (BPM*) is considered to be a process by itself that ensures continued improvements in an organization's performance, which requires leadership, and guidance in:

- Taking a radical-change perspective;
- Fundamental tenets of the process are under re-examination and maybe renewal;
- Process might undergo a cycle of continuous review and enhancement with minor adjustment being considered;
- Process's fit with other processes should be understood, examined, and challenged.

According to Bentley et al. [2001], the BPM can also be defined as an on going activity that documents, manages the use of, and improves an organization's chosen methodology (the processes) for systems development. It is concerned with activities, deliverables, and also quality standards to be applied to all projects.

1.7.2 Modelling In Engineering and Business Design

The Canadian Engineering Accreditation Board (CEAB) has described engineering design as a "creative, comprehensive and often open-ended processes, which integrate mathematics, basic sciences, engineering sciences, engineering economics and other subjects as well as experience for creation of components, models, systems, products and processes to satisfy specific needs and constraints".

These constraints include economic, safety, health, environmental, and social factors. That also includes requirements of standards and also legislation and other considerations such as reliability, maintainability, serviceability and manufacturability.

Dixon and Corrado [1995] have considered the term "design" as knowledge. It is knowledge of physics, chemistry, mathematics, static, materials, strength of materials, thermodynamics, fluids, heat transfer, instrumentation, analysis, and computers that all come together. In addition, history, psychology, literature, economics, sociology and philosophy are considered as design's content. In addition, this term involves a person's character, creativity, values, as well as his/ her human understanding.

The term “Business Design” is composed of two terms. A business is its "processes, systems and people". Design is "an underlying scheme that governs functioning, developing, or unfolding". The business designer is the person who puts design into the business of the owner and strategist. The business designer must understand business strategy, BPR, management finances, Information Technology (IT) and human resources.

Looking into the engineering and business design definitions, it is very clear that they can be considered as one term. The business design framework gives business analysts a structure within which they can use their tools, methodologies, methods and business models. The whole enterprise can understand, manage and implement worlds best practice business design [Voland, 2001; IBD Innovative Business Design, URL: http://www.innovativebusinessdesign.com/].

A model is a representation of a set of components of a system or subject area. It is developed for understanding, analysis, improvement or replacement of systems. Such systems are composed of interfacing or interdependent parts that work together to perform a useful function. Moreover, the system parts can be any combination of things, which might include people, information, processes, equipment or products.

It is important to mention here that the model describes what a system does, what controls it, what things it works on. In addition, it describes what means it uses to perform its functions, and also what output it produce, service and deliver to the users or customers.

A model can also be defined as a representation of reality, built for existing systems as a way to better understand those systems or proposed ones to document business requirements or technical design [Bentley et al., 2001].

According to Noran [2004], a model can be defined as a simplified abstract view of the complex reality which may focus on particular views, enforcing the 'divide and conquer' principal for a compound problem.

A model in the business domain represents a concept on how the business functions and how it includes targets, vision, efficiency, and other important factors. A model must have a purpose where in the business domain, the purpose will be to understand its structure, improve it or also re-engineer it. Also, the model's shape and details are highly dependent on its objectives.

The business model should be considered as a basis of the (IS) model. That will assist in insuring consistency and accurate requirements being passed on the tool design. Understanding of the business and its opportunities can be achieved by understanding the business model. BPM is a technique for organizing and documenting the structure and flow data through systems and/or the logic, policies and procedures to be implemented by systems processes. It enables a common understanding and analysis of a business process.

An enterprise can be analysed and integrated through its business processes. According to Berio and Verndat [1999], enterprise modelling can be defined as "the art of developing models which accurately represent the structure and behaviour of a business entity". Enterprise models are made of sub-models such as organisation models, process models, data models, configuration models or plant layout models, among others. There are two main reasons of these models. Providing a common understanding among users about enterprise operations is the first one. The second one is to structure support analysis or decision-making. Noran [2004] has stated that there are few stages that might be identified in the purpose of business modelling where that includes:

1. Business goals are set, and resources allocated by the owner;
2. Business structure together with its processes are created by the business modeller;

3. Put step two in mind, system developers design and also develop suitable IS to support the business.

A business process model typically defines the goal or reason for the process, specific inputs, specific outputs, and resources consumed. It also assists in defining activities performed in some order and events that drive the process. [Sparks, 2000]

CHAPTER 2

LITERATURE REVIEW

2.1 Business Process Reengineering And Workflow Management

The BPR is a term often used to describe the collection of methodologies, used to model existing and develop new business processes. Hammer and Champy [1993] has defined the BPR as the fundamental rethinking and radical redesign of business processes. Its objective is to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, and service.

The BPR has been used successfully by a number of organizations to restructure the way they perform work. Because of its success, many organizations are beginning to rethink the role of organization structure and conclude work should be organized around the business process. Based on the experience of its early adopters, BPR offers a set of methodologies, which can assist organizations in redesigning core processes to meet today's challenges. Also, its use pervades an organization, become a powerful instrument for organization transformation [Simon, 1994].

The difference between BPR on the one hand and problem solving activities on the other hand has hardly any effect on process structuring. For instance, both business and problem solving processes can be ordered in a hierarchical as well as in a sequential manner. The problem solving process is embedded in the BPR so it can be viewed as a fine-grained business process on its own. This perception is modelled via inter-view-links, connecting the expertise view with the process view. Two links define relationships between a problem-solving method and a process as well as between a problem task and a task. Another link relates job part process and problem task.

Work Flow Management (WFM) can be defined as a technology that automates processes, involving combinations of human and machine-based activities within an office environment and making use of IT applications and tools. Its usefulness to support the automation of business processes in offices as well as manufacturing areas, has led the Work Management Systems (WMS) to become very popular the last years [Kosanke, 2000].

The workflow applications are often chosen as a technological enabler for business processes. This involves many employees on different locations and/or need better system integration. That will also include better process control, higher quality, and/or improved customer focus. The BPM has four main objectives, first is acquiring explicit knowledge about the business processes of the enterprise operation. Second is exploiting this knowledge in business process. Reengineering the projects to optimise the operation is the third objective. The final objective is to support the decision-making activities of the enterprise and to ease interoperability of the business processes. With the advent of inter-organisational collaboration, objectives two and three depend heavily on the interoperability of business process models. Only if the business process models of collaborating organisations can be linked into a model of the envisioned enterprise, its "TO-BE" operation can be analysed and optimised. Collaboration of engineering processes and systems deals with the development and use of participative methods and tools. This includes quantitative and qualitative analysis of current business processes and also for the design and implementation of new ways of working. Though it does not focus on the production and assembly of goods, it captures the administrative processes that occur in all public and private organizations [Kosanke, 2000; Sola et al., 2000].

The basis for the development of enterprise specific workflow applications can be considered to be the process models. The models describe the process structure and logic on a type level the workflow application supporting the execution of single processes on the instant level. Sola et al. [2000] has referred to an alternative approach to workflow design. In this approach, organizational stakeholders play an active and important role in collaboratively re-designing an organization's processes. The researched work has provided collaborative BPR approach to achieve better results than traditional non-collaborative approaches.

In addition, the definition of a process model in a WMS results in a particular workflow application and the available WMS integrate modelling systems for the graphical definition of process models. When comparing different existing architectural frameworks for the BPM, it is obvious that the functionality of these systems and their modelling concepts are quite poor. They do not support the separate construction of models in views like data, organization, function and their integration in a central process view.

The aptness of modelling methodologies is very much dependent on the purpose of modelling. As a response, systems analysts and developers have introduced different modelling approaches. Moreover, some modelling efforts might be primarily descriptive by nature. In other cases, an optimized implementation solution is sought and the analyses have to be supported by evaluation tools. This requires an easy and clear process description, which is far detailed for descriptive purposes.

2.1.1 The Beginning Of Business Process Analysis And Development

A company's road map can be defined as an outline of a business that covers what the company does and how it works. It allows management to see how functions are performed and it helps analysts determining what to do first and where to go after that. It is determined that any business needs a map because firstly; it can reduce work by insuring that nothing will be missed in analysis. Secondly; it can reduce long-term maintenance costs by including everything at the outset. Thirdly; the map can shorten the development cycle through the elimination of having to back up and cover some unseen event [Bauer, 1992].

A company's map can be considered as a picture of business functions. It allows managers to see how functions are performed, and analysts to decide what to do first and where to go afterward. The map may suggest where productivity improvements might be achieved and also from where analyses should start.

The company's map assists a business in reducing work where there will be insurance that no information will be missed while conducting analyses. It also assists management by programming, managing and also budgeting for all areas of efforts. It also reduces long-term maintenance costs by including everything at the outset. More and more, it provides better management and it shortens the development cycle through the elimination of having "back up" and covers some here-to-fore unseen event [Bauer, 1992].

The company's map consists of diagrams that show how work gets from one place to another and what the stops are along the way. There is a description of what is available at each stop. The map does not have to be a graphic but picture is work a thousand words and is sometimes more communicative then text. A graphic is also sometimes less open to human interpretation than text is.

There are three elements that are required when communications in the map and they are as follows:

1. Procedure;
2. Method and Interface;
3. Activity and functional modelling to be describes in details at a later stage of this chapter.

Mr. Bauer stated that the map must show the company's procedures and methods, where the interfaces are in performing work and also the work efforts that go into making business what It Is. More and more, decisions must include real productivity and quality increases associated with them. A company's map should be 'drawn' to understand where there might be an improvement. Expensive efforts of analysis and development will be expected without a map, which will lead into the Absence of Proper Work Effort interfacing [Bauer, 1992].

More and more, there are two major advantages while using the company's map, first is preventing major mistakes and second is reducing the need and cost of correcting minor mistakes. Such Implementation of the map will help the company to become more efficient.

Without a map, the efforts of analyses and development can turn out to be very costly. That is due to a lack of proper work efforts interfacing or perhaps not considering some work efforts at all. Making the company more efficient, preventing major mistakes and reducing the need, and coat, of correcting minor mistakes is a necessity and can be helped with a map [Bauer, 1992].

2.1.2 Enterprise Business Process Success

Improving the use of information is the main concern of enterprises. In the past, business developers have tried implementing all business development methodologies. That included total quality management, just in time, supply chain management, data warehousing and electronic communications.

There is a competitive demand toward product flexibility, throughput, and quality together with low costs and also short lead-times. That will be achieved by finding the right system of measurements, along with better ways to build and deliver the right information to the right people at the right time. This will be resulting in building a promise for better information management and effective knowledge delivery [Pearson, 1999].

It is very important for any business or service provider to satisfy its customers, shareholders, and employees. Although it may appear to be an easy mission to be accomplished, however, operational complexities can be a reason for making this not easy as it sounds. Continuous changes in operations management, confusion with operations management, conflicts in priorities, disagreement for resources, and communication problems combine all together in causing a barrier to good operations management and enterprise improvement.

To ensure enterprise success, business, technology, and human elements need to be integrated and balanced. That can be demonstrated in Figure 2.1 where it includes three spheres representing the business, technology, and also human elements. In addition, the area of overall success is the overlapped one and the areas between any two spheres are the interfaces of interest [Pearson, 1999].

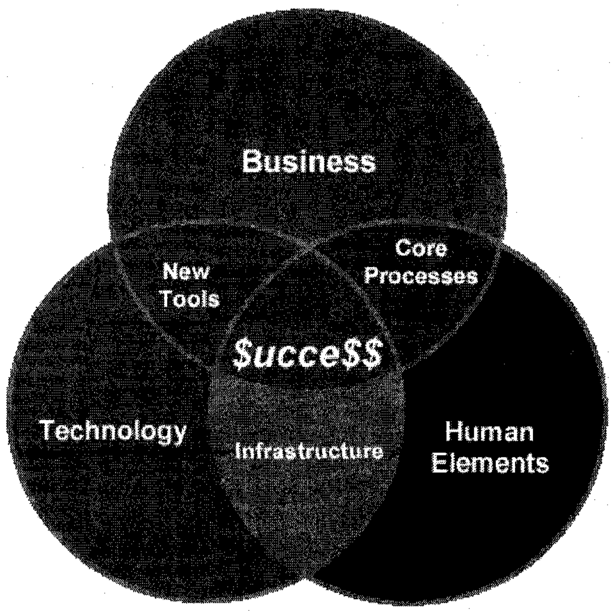


Figure 2.1: Integrating The Enterprise [Pearson, 1999]

According to Mr. Pearson, "The best way to increase the mutual overlap (enterprise success) is to expand all three interfaces in balance". That is demonstrated in Figure 1.2 where these areas may be thought of as the information infrastructure, processes, and tools for improved knowledge development and delivery".

Each of the interfaces comprises multiple disciplines and serves multiple levels of the enterprise. Increase the overlap requires comparing and contrasting various disciplines, and explores creative ways to combine them more effectively. Also, the opportunity for improvement is in the interfaces where innovation relies on combining known things in unknown ways. That requires for looking at the overall infrastructure for continual knowledge development and delivery.

Success of the enterprise business processes will increase if all three spheres are brought into closer alignment. Enterprise success will be reduced however if at least one of the spheres is neglected and that can be viewed in Figure 2.2 below:

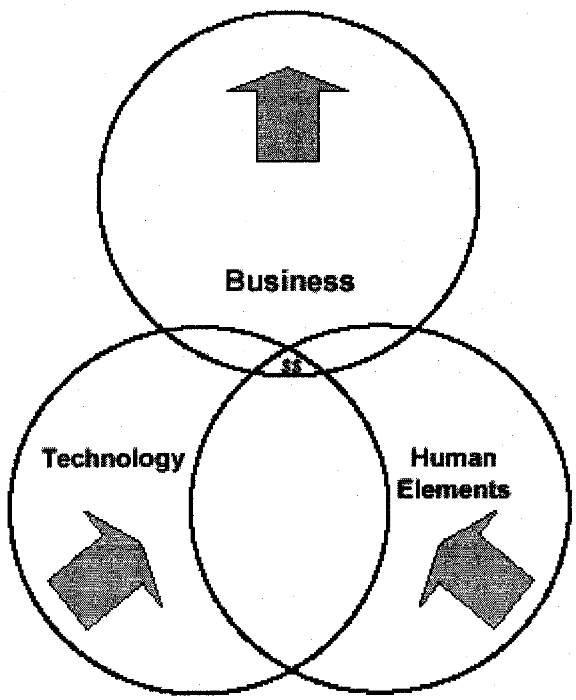


Figure 2.2: Reduce Enterprise Success [Pearson, 1999]

2.2 The Six Stages Of The Business Process Reengineering

2.2.1 Strategic And Business Planning

Planning can be divided into two levels, namely, strategic and business planning. The strategic planning looks outward to create context where the business unit functions with respect to its defined mission.

Business planning targets the inward view to collect available resources in pursuit of the vision. Definitive objectives and quantitative measures of performance to guide progressing efforts' are the main basis that both levels rely on. This stage includes five essential steps described as follows:

1. Develop or validate strategic plan;
2. Develop or validate business systems plan;
3. Develop or validate annual business plan;
4. Construct performance measures for processes; and
5. Establish process improvement project.

Benefit of the planning stage can be achieved where the development team begin their work with a clear understanding of their mission. In addition, a sense of what a successful performance will look like. That will request also to focus on how to achieve the process vision and performance objectives set by senior level management.

2.2.2 Business Process Reengineering Level

Mainly, this stage focuses on the reengineering level of the process improvement since there is no definitive existing roadmap for every possible reengineering effort. The composition of this stage can be described as follows:

1. Conduct baseline analysis that includes analysis methodologies that include information, data, and process modelling, Activity Based Costing (ABC);
2. Conduct improvement analysis that includes documentation of performance gaps and identification of improvement opportunities;
3. Redesign/reengineer processes where it is considered to be a multi-task step producing final process design specifications;
4. Prepare Functional Economic Analysis (FEA) decision pack.

2.2.3 Organizational Change Management

Changing to an organization's structure and culture can be considered the cause of the BPI. The rule of the organizational change management team is to ensure that the structure of the organization and culture will be able to successfully incorporate the improved process.

Moreover, the structural change management includes the way a functional unit is organized to carry out its work responsibilities where it has to do with things or facilities. Cultural change management is concerned with the way people interact with each other. It is believed to be more difficult than the structural change management to be successfully performed.

2.2.4 Technology Change Management

The usefulness of advanced technology can potentially enhance an organization's ability to achieve main improvements in the following measurement categories:

1. Fitness-for-Purpose which provides the means to deliver high standard customer service by enabling organizations to easily and inexpensively customize services and products to meet customer requirements;
2. Conformance-to-Standard technology, which assists to achieve the exact quality standards, resulting in reducing defects, and wastes;
3. Investing in a new technology always requires initial resources and start-up costs, (Process Costs). Moreover, the Return On Investment (ROI) can often be measured in orders of magnitude, especially in service-based processes;
4. Deploying new virtual technology can be considered the only way to minimize the operational time (Process Cycle Time) required to produce an output unit.

Potentially, the assignment of the successful enterprise is based on assessing its technical capability. This is achieved by comparing strengths and weaknesses of whatever existing technology implemented with redesigned process requirements and emerging technology. Identifications of all technical change requirements are next and then developing a change management plan.

The enterprise's system developers involved in the work will then make a plan that align process improvement with potential technology enablers and address all technological barriers to implementing redesigned processes. While the improvement mission progress through the enterprise engineering and project execution stages, the change management team will then coordinate technology-based actions with process improvement actions [KBSI, 2000].

2.2.5 Enterprise Engineering

At the very early of this stage, no real progress has been accomplished yet in terms of reducing costs, decreasing cycle time, and also improving quality and service. Till reaching this stage, the BPI team has identified a series of process, organizational, and technical changes. That will assist in leading to quantifiable improvements in overall process performance when such changes are implemented.

To this level of work, the performance is similar to developing blueprints and constructing system components. The work in final stage is concerned with installation, assembly, and deployment of the engineered process and supporting systems. Moreover, there are three main steps in this stage summarized as follows:

1. Configure a technical platform to support process information and communication requirements;
2. Develop, test, and provide documentation for the database structures for such requirements;
3. After that, design a systems integration plan addressing the need to develop migration systems to replacing ineffective existing or legacy systems.

2.2.6 Project Execution

The "TO-BE" process is assumed to be designed at this level including activity and data models by the enterprise' process team where the new process supported by the IS has been constructed and tested.

In this stage, the organizational change management plan have been developed and approved. That includes the development of the new management structure, work methods, and work flows.

Also, all documentations, procedures, and forms are designed and ready to be deployed. In addition, there will be training systems to be placed and tested. Also in this stage, support structure for the reengineered process and its underlying (IS) is be completed and tested.

The process team will then install and deploy the improved process within the organization where the required installation and deployment process must be well planned and correctly executed [KBSI, 2000].

It is vital to mention in this part that any critical problems at this stage can disrupt business operations. It also can confuse and frustrate stakeholders resulting in irreparable harm to the enterprise as a whole. Because of that, there are five crucial steps for the objective of securing the project success during this stage and are summarized as follow:

1. All approved project-related documents need to be reviewed for developing a project management plan for systems installation and deployment;
2. IS need to be installed and tested, then the need for implementing training programs and a transition plan, and decommission obsolete IS;
3. Organize an organizational change management plan, where it will include revised policies, finalizes organization realignment. Also, finishing transition to the new process and IS;
4. Function and maintain process and IS. That will include the identification and resolution of issues, and the preparation of regular status reports;
5. Maintain Continuous Process Improvement (CPI) by reviewing status reports and consulting with employees and other stakeholders for the objective of determining all possible improvement opportunities.

2.3 Business Processes And Work Flow Modelling

2.3.1 Complexity In Business Processes Modelling

The question that needs to be asked is What Makes processes complex? Biemans [2001] has linked the answer to the structure of business processes including the variety of elements and relationships between them in the business processes.

Two aspects need to be considered while looking into the variety of the elements. First, the business processes typically involve several knowledge domains, for instance, a bank that functions a mixture of people with financial, commercial, technical, legal, or social backgrounds. Business processes, often executed by computers and people, deal with several of these domains.

The second aspect includes the business processes that operate on different time scales. For instance, payment transactions occur in split seconds; on the other hand, personal data about cardholders may remain unchanged for years.

It is very clear that aspects of business processes are perceived as stable however in fact they are changing slowly. Obviously, the varying time scales make it difficult to understand business processes. With respect to the variety of relations, business processes are often nearly independent. They seem to be independent, but in fact exchange information at certain points in time [Biemans, 2001].

When number of elements or relationships increases, there is more attention required to understand and classify the sorts of the elements and relationships. The complexity in business processes can be considered to be is partly subjective whether human beings perceive things as being complex depends on their background. This observation has assisted to determine another cause of complexity where different persons are involved in business systems, experts in different fields, and the people that are to carry out the business processes does not exist. They all speak a different language, which reduce the integration of a common understanding.

In addition, different people, with their different objectives, and experiences modify the existing business processes resulting of entangled processes that hardly resemble the original design. The issue to hint about in this part, that the change in business processes stays complex. This is because it resists the large-scale overhauls and clean-ups necessary to install a modular structure that will successfully assist to oversee the business processes. That can be caused by lacking of time and also the natural resistance to change processes developed at high costs and still work one way or another.

Structured frameworks known as enterprise architectures can capture and manage the complexity of today's organizations. Organizations are systems composed of elements such as objectives, data, people, processes and technology. Coordination and integration are required by highly complex systems in order to manage the existing interdependencies between all these components. However, if these interdependencies are not sufficiently accounted for, silo solutions and isolated systems with an increased level of complexity may result as a consequence.

According to Suh [1999], there are two kinds of complexities in the time-independent situations. They are real and imaginary complexities, which are orthogonal to each other. Absolute complexity is defined to be a vector sum of the real and the imaginary complexities. Time-dependent complexity composed of two types, the first one Combinatorial and the second one is and periodical. In a system of a combinatorial complexity, the uncertainty of the future outcome continues to grow as a function of time.

Finally, mastering the complexity of the business process design must be the systems developers' main concern. Business processes appear to change so fast and so inconsistently that it seems impossible to control. Mastering the complexity of the business processes will be a successful task if they are modeled and analyzed before they are modified [Biemans et al., 2001; Frizelle, 1998].

2.3.2 Unified Modelling Language

There are large numbers of modelling methodologies that are currently in use to support application development for representing organisational aspects and system aspects as well. Graphical modelling methodologies can be considered to be the most suitable for communication and visualisation purposes in the architectural context.

The Unified Modelling Language (UML) is a standard modelling language for the specification, visualisation, construction and documentation of software systems artifacts. It is very widely used to model systems, and also offers methodologies for organisational and process modelling. It is made up of a very specific notation and the related grammatical rules for constructing software models. It does not proscribe or advise on how to use that notation in a software development process or as part of an object-oriented design methodology. The UML supports a rich set of graphical notation elements. It describes the notation for components, nodes, activities, workflow, and objects. It assists in modelling relationships between these elements.

The UML originates from a number of Object Oriented Methods (OOM) for systems design. According to Saven [2003], the OOM can be defined as methods to model and program a process described as objects, which are transformed by the activities along the process. The fundamental construct is the ''object'', which combines both data structure (attributes) and behavior (operations) in a single entity. Objects may represent real world applications. The OOM provide a set of concepts and language elements that can be used to model different aspects. This includes the use-case diagrams, which show the actors, and class. Also, the object diagrams assist in defining objects and their behaviour as well as their states [Sparks, 2000; ElMaraghy, W., 2000(a)].

Moreover, several software development methodologies and tools use the UML as a basis of their contents. The UML provides a collection of diagrams used to model a system from different perspectives. That can be grouped into two categories. The first category is the structural diagrams. They are used to visualise, specify, construct, and document the static aspects of a system. More and more, the UML provides four types of structural diagrams: class diagram, object diagram, component diagram and deployment diagram. Behavioural diagrams (second category) are used to visualise, specify, construct and document the dynamic aspects of a system. Also, the UML provides five types of behavioural diagrams including the use case diagram, state chart diagram, activity diagram, sequence diagram and also the collaboration diagram [Arbab, 2002].

Modelling the business processes is considered to be vital part of any software development process. It assists analysts to capture the broad outline and also procedures that govern what it is a business does. The BPM can provide an overview of where the proposed software system being considered will fit into the organisational structure and activities. That provides clear justification for building the system by capturing the current manual and automated procedures rolled up into a new system, and the associated cost benefit [Sparks, 2000].

Modelling business activities allows the analyst to capture the significant events, inputs, resources and outputs associated with business process. This is will be achieved by connecting design elements to the BPM through implementation links. Because it has a broader and more inclusive range than just considering the software system, clearly, the BPM allows the analysts to map what is in the scope of the proposed system and what will be implemented in other ways.

Sparks [2000] defined business process as a "collection of activities designed to produce a specific output for a particular customer or market". It implies a strong emphasis on how the work is done within an organisation, in contrast to a product's focus on what. A process is a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs: a structure for action. A business process's notation is demonstrated below in Figure 2.3 below.

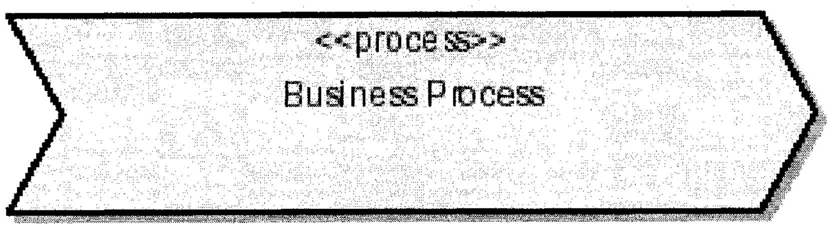


Figure 2.3: Business Process Notation [Sparks, 2000]

This process notation demonstrates a flow of activities from left to right. Where the event element is placed to the left of the process, its output is placed to the right one. The UML activity elements may be placed inside the process element to specifically notate the internal activities.

Information might be gained from customers, external sources, or from internal organizational units. It could be also achieved from a product of other processes. It is utilized by business process to complete their activities. However information is not consumed in the process, it is used as part of the transformation process.

Information is an asset, consumed during the process and a resource. It can be considered as an input to a business process. Information and resource's notations are illustrated in Figure 2.4 below:

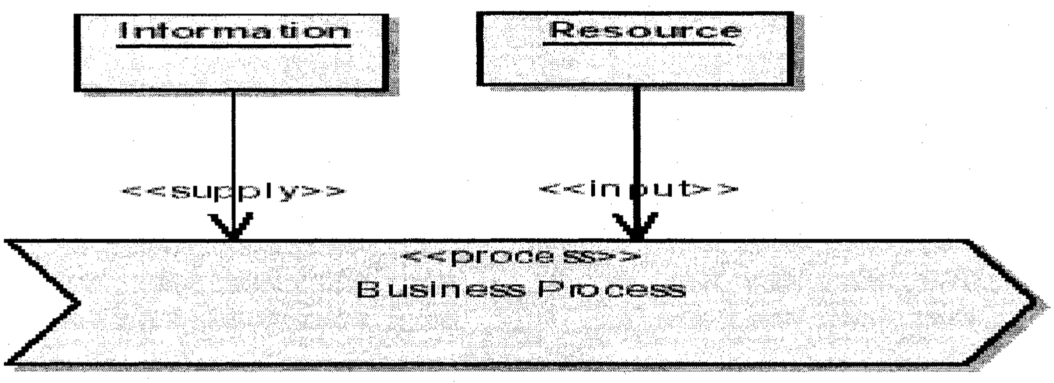


Figure 2.4: Notations OF Information And Resources [Sparks, 2000]

From the supply link demonstrated in Figure 2.4, the information or object linked to the process is not used up in the processing phase. The input link indicates that the attached object or resource is consumed in the processing procedure. As illustrated in Figure 2.5, an event can be considered as the receipt of some object. It could be also a time or date reached, a notification or some other trigger that initiates the business process. The event may be consumed and transformed or it can be considered as a catalyst to the process.

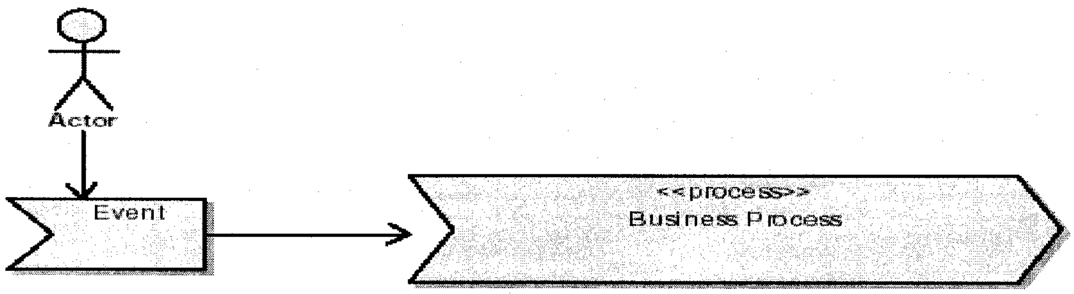


Figure 2.5: Business Process Event [Sparks, 2000]

Business process output may be a physical object, a transformation of raw resources into a new arrangement, or an overall business result. This is illustrated in Figure 2.6.

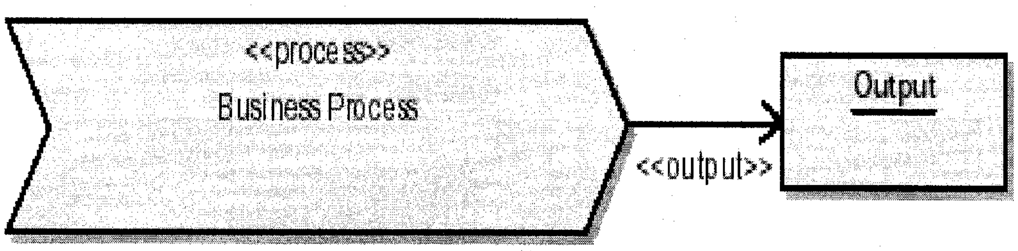


Figure 2.6: Business Process Output [Sparks, 2000]

As illustrated in Figure 2.7, very well determined goals from the business process where that is the reason why organization does invest in the business process. A goal is the business justification for performing the activity. Such goals should be defined in terms of the benefits this process will provide, for the organization as a whole and in satisfying the business needs.

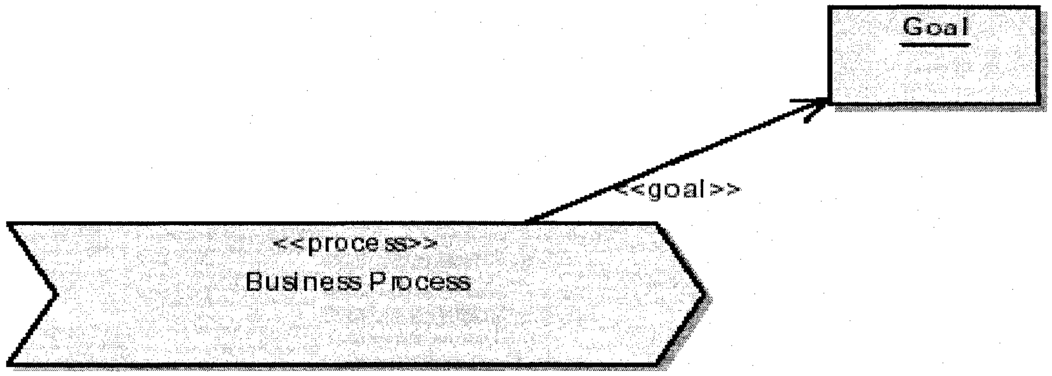


Figure 2.7: Business Process Goal [Sparks, 2000]

A logical picture of a business process will result when various model elements are grouped together. That will include inputs, outputs, events, goals and other important resources, as illustrated in Figure 2.8 below:

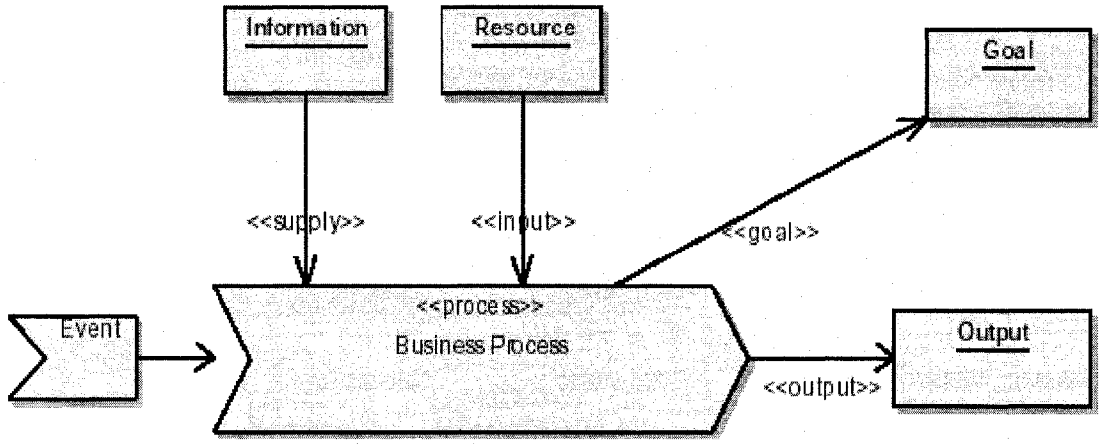


Figure 2.8: A Logical Picture Of A Business Process [Sparks, 2000]

2.3.3 Zachman Framework

Enterprise architectures present a conceptual map of an organization from many perspectives – from business, applications, information and technological points of view. The conceptual map is a mandatory requirement for various management tasks such as Business Process Engineering (BPE).

Building enterprise architectures requires identification and consolidation of information about the organization from different perspectives. The relevant questions are: who is doing what, and how, where and when, but above all why? These questions reflect the main dimensions of an organization: data (what), functions (how), networks (where), organizational structure (who), schedule (when) and strategy (why).

According to Schallert [2001], the "enterprise architectures design" involves developing of a methodology to establish a basis for complexity management and change management. That also includes the lifecycle concept of IS in order to bridge the gap between strategy and implementation. Comprehensive modelling methodologies are also included to capture the entire organization, and a sophisticated modelling tool in order to build and maintain enterprise architecture efficiently.

The Zachman's framework for IS architecture was first proposed by Mr. John Zachman in 1987 and later extended in 1992. It is a widely used approach for developing and/ or documenting enterprise-wide IS architecture. Mr. Zachman has based his framework on practices in traditional architecture and engineering. It is an influencing framework for modelling IS architecture.

The "Framework for Enterprise Architecture" cross-references elements such as business objectives and scope, enterprise business models, IT models and technology models against perspectives such as data, processes, networks, people and time. The approach covers multiple dimensions has achieved high levels of popularity in the domain of enterprise modeling [Schallert, 2001].

When Mr. Zachman first published the “Zachman framework” for enterprise architecture, he wrote " To keep the business from disintegrating, the concept of IS architecture (ISA) is becoming less of an option and more of a necessity". According to Schallert [2001], Zachman's framework for enterprise architecture proposes a structured set of perspectives and levels. This is to define and describe today’s complex organizations. It applies a generic classification scheme to represent a complex object. The advantage of such a scheme is to focus on single aspects while at the same time taking a holistic perspective. This advantage is important for the management and continuous development of an organization. The Zachman framework is influenced by principles of classical architecture that establish a common vocabulary and set of perspectives for describing complex enterprise systems. This influence is reflected in the set of rules that govern an ordered set of relationships that are balanced and orthogonal.

The Zachman framework provides a view of subjects and models. They are required to develop complete enterprise architecture. As the framework identifies the primitives that make up enterprise architecture, it is pretty difficult to not use at least some of them. Figure 2.9 demonstrates the standard presentation of the Zachman framework. The columns of the framework provide the common sense rules that describe a story or explain an object. These rules are: Who? What? When? Where? How? and Why?

The rows of the framework provide increasing greater level of detail as required by various observers or listeners to a story. While some observers require only a very high level of detail, some require an in-depth, technical description of the story. Moreover, the purpose of the framework is to provide a basic structure which supports the organization, access, integration, interpretation, development, management, and changing of a set of architectural representations of the organizations IS. Such objects or descriptions of architectural representations are usually referred to as artifacts. The framework, then, can contain global plans as well as technical details, lists and charts as well as natural language statements. Any appropriate approach, standard, role, method, technique, or tool may be placed in it [Zachman, 1999].

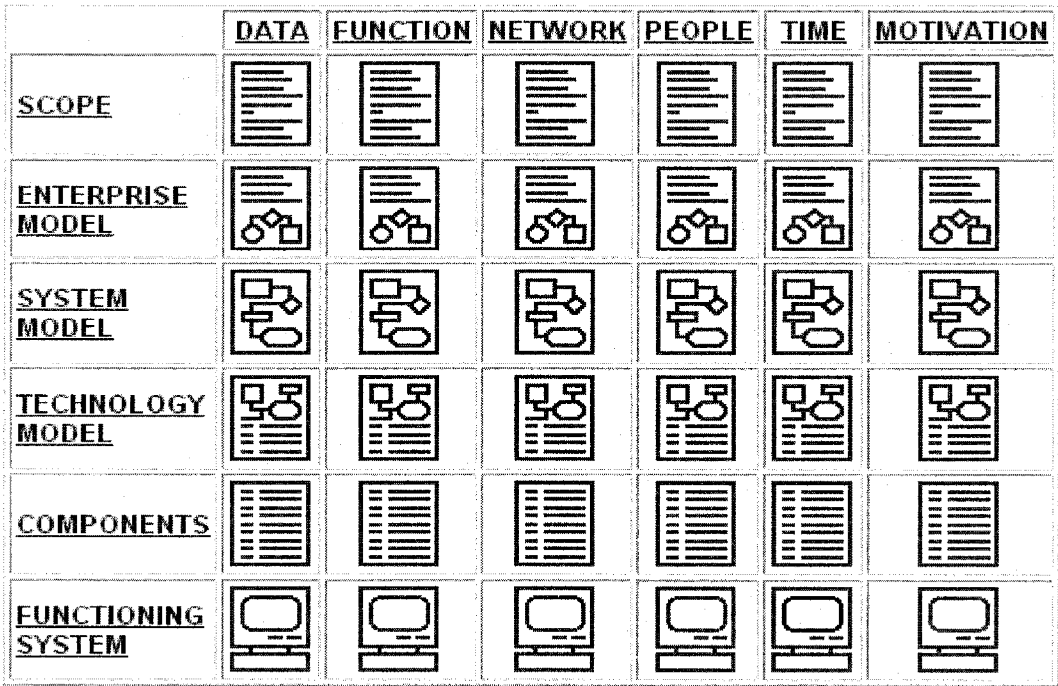


Figure 2.9: The Zachman Framework [Zachman, Http://Www.Istis.Unomaha.Edu/Isqa/Vanvliet/Arch/Isa/Isa.Htm]

This framework can be viewed as a tool to organize any form of meta-data for the enterprise. Multiple perspectives of the overall architecture are provided on the vertical axis. On the horizontal axis, a classification of the various artifacts of the architecture is given. The Zachman framework demonstrated above in Figure 2.9 describes a holistic model of an enterprise's information infrastructure from six perspectives. They include the planner, owner, designer, builder, subcontractor, and the working system. There is no guidance on sequence, process, or implementation of the framework. The focus is on ensuring that all aspects of an enterprise are "well organized" and exhibit "clear relationships" that will ensure a complete system regardless of the order established [Zachman, Http://www.Istis.Unomaha.Edu/Isqa/Vanvliet/Arch/Isa/Isa.Htm].

The major principles that guide the application of the Zachman Framework include:

1. A complete system can be modeled by depicting answers to the questions why, who, what, how, where, and when;
2. The six perspectives capture all the critical models required for system development;
3. The constraints for each perspective are additive; those of a lower row are added to those of the rows above to provide a growing number of restrictions;
4. The columns represent different abstractions in an effort to reduce the complexity of any s ingle model that is built;
5. The columns have no order;
6. The model in each column must be unique;
7. Each row represents a unique perspective;
8. Each cell is unique;
9. The inherent logic is recursive.

The Zachman framework is a simple concept with powerful implications. By understanding any particular aspect of a system at any point in its development, system designers construct a tool that can be very useful in making decisions about changes or extensions. The framework contains six rows and six columns yielding 36 unique cells or aspects. This can be seen in the framework diagram illustrated in Figure 2.9. The rows and the columns are separated as follows in Table 2.1 and Table 2.2 respectively:

Table 2.1: Zachman Horizontal Aspects [Schallert, 2001]

Zachman Horizontal Aspect	Definition
Scope	Corresponds to an executive summary for a planner who wants an estimate of the size, cost, and functionality of the system.
Enterprise Model	Shows all the business entities and processes and how they interact.

Table 2.1: Zachman Horizontal Aspects [Schallert, 2001] (Continue)	
System model	Used by a systems analyst who must determine the data elements and software functions that represents the business model.
Technology Model	Considers the constraints of tools, technology, and materials.
Components	Represent individual, independent modules that can be allocated to contractors for implementation.
Functioning System	Depicts the operational system

Table 2.2: Zachman Vertical Aspects [Schallert, 2001]

Zachman Vertical Aspect	Definition
Who	Represents the people relationships within the enterprise. The design of the enterprise organization has to do with the allocation of work and the structure of authority and responsibility. The vertical dimension represents delegation of authority, and the horizontal represents the assignment of responsibility.
When	Represents time, or the event relationships that establish performance criteria and quantitative levels for enterprise resources. This is useful for designing the master schedule, processing architecture, control architecture, and timing devices.
Why	Describes the motivations of the enterprise. This reveals the enterprise goals and objectives, business plan, knowledge architecture, and knowledge design.

Table 2.2: Zachman Vertical Aspects [Schallert, 2001] (Continue)	
What	Describes the entities involved in each perspective of the enterprise. Examples include business objects, system data, relational tables, or field definitions.
How	Shows the functions within each perspective. Examples include business processes, software application function, computer hardware function, and language control loop.
Where	Shows locations and interconnections within the enterprise. This includes major business geographical locations, separate sections within a logistics network, allocation of system nodes, or even memory addresses within the system.

2.3.4 Computer Integrated Manufacturing Open System Architecture

Enterprise modelling can be considered as a crucial step both for enterprise engineering and enterprise integration. It is concerned with representation and analysis methods for design engineering and automation of enterprise operations at various levels of details. In addition, it applies to the modelling of material, information and control flows of the enterprise. This is with respect the function, information, and resource or organization viewpoint. The complexity of modern enterprises makes enterprise modelling a major issue. The need for integrating several different features requires a powerful modelling technique, such as the Computer Integrated Manufacturing Open System Architecture (CIMOSA). This is required to represent functional, control, informational and organizational aspects.

The CIMOSA is an-open systems architecture for the Computer Integrated Manufacturing (CIM). It is based on a three stage, process-based enterprise modelling approach, partly covering the enterprise life cycle. It covers functional/ behavioural, information, resource, and organisation aspects of an integrated enterprise at various modelling levels. It structures CIM systems as sets of distributed, co-operative agents (called functional entities) linked by an integrating infrastructure to timely execute the many concurrent business processes of manufacturing enterprises.

According to Williams [2000], CIMOSA separates functions using two interrelated concepts. The first one is "CIMOSA modelling framework" where specific and generic functions are separated. The second concept is "CIMOSA integrating infrastructure". It supports the execution of generic functions and links specific functions. Effectively, it is considered to be the communication system that interconnects all of the functions in the CIM system. Berio and Verndat [1999] defined CIMOSA as an open system architecture, developed for integration in manufacturing but widely applicable to integration of any type of enterprises.

Four modelling views are defined within the enterprise functions of CIMOSA. They are as follows: the function view, which describes workflows, is first. Second is the information view, which describes the inputs and outputs of functions. Resource view, that describes the structure of resources (humans, machines, and control and IS) is third. The fourth view is the organisation view, which defines authorities and responsibilities

The CIMOSA modelling framework as illustrated in Figure 2.10 provides the user with architectural constructs and guidelines for the structured description of business requirements and their translation into CIM system design and implementation.

Derivation process guides the user through the three modelling levels. The first level is the requirements definition of the enterprise business. That will be followed by the optimization and specification of the requirements (design specification). Implementation description is the third level. On each modelling level, the enterprise is analysed from different viewpoints.

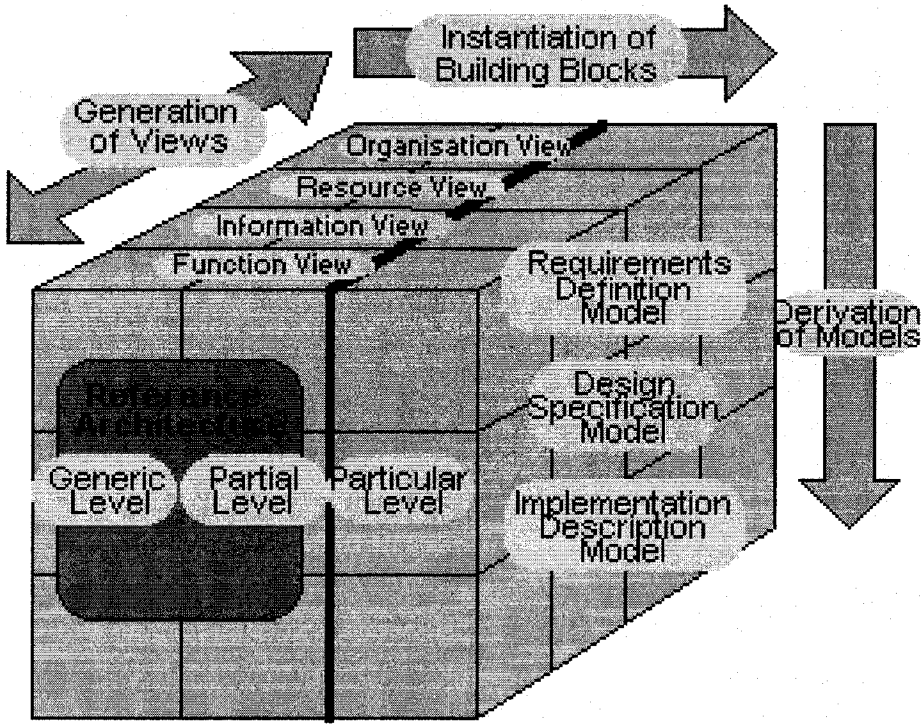


Figure 2.10: CIMOSA Modelling Framework [The CIMOSA Association, Http://Cimosa.Cnt.Pl/Docs/Primer/Primer5.Htm]

The CIMOSA defines three levels of "genericity" from purely generic to the highly particular. This is to minimize modelling effort. The first "generic" level is a reference catalogue of basic CIMOSA architectural. It is developed for components, constraints, rules, terms, service function and protocols. The second partial level includes a set of partial models applicable to a specific category of enterprises. The third particular level is related to one particular enterprise. It is defined in the instantiation process by the modeller using prepared building blocks from the generic and partial level. It also assists in developing new particular enterprise specific components. The CIMOSA model of an enterprise can be released (Integration Process) for the execution in the CIMOSA Integrating Infrastructure (IIS) environment after the modelling process is finished. The IIS as illustrated in Figure 2.11 enables CIMOSA models to be executed. It allows the control and monitoring of enterprise operations as described in the models.

Furthermore, it provides a unifying software platform to achieve integration of heterogeneous hardware and software components of the CIM system. The integrating infrastructure is made of a number of system-wide, generic services. The business services control the enterprise operations according to the model. The information services provide for data access, data integration and data manipulation, and the presentation services act as a standardised interface to machines, applications and humans.

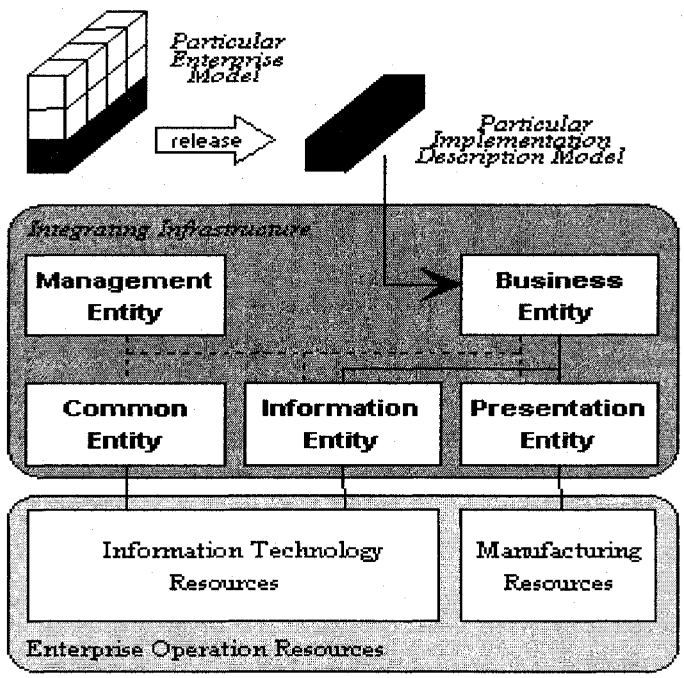


Figure 2.11: CIMOSA Integrating Infrastructure
[The CIMOSA Association, Http://Cimosa.Cnt.Pl/Docs/Primer/Primer5.Htm]

A product that is connected to the presentation services can be attached and removed without changing any other part of the (IT) environment [The CIMOSA Association, Http://Cimosa.Cnt.Pl/Docs/Primer/Primer5.Htm].

2.3.5 IDEF$_0$ Design Methodology

2.3.5.1 Background

During the 1970s, the U.S. Air Force program for Integrated Computer Aided Manufacturing (ICAM) has demanded to increase manufacturing productivity through systematic application of computer technology. The ICAM program has helped to identify the need for better analysis and communication methodologies for improving manufacturing productivity. Also, the ICAM program has developed a series of methodologies known as the IDEF (ICAM Definition) that are summarized in Table 2.3 below:

Table 2.3: $IDEF_x$ Implementation
[Draft Federal Information Processing Standards Publication 183, 1993]

IDEF Technique	Implementations
$IDEF_0$	Implemented to produce a "Function Model" which can be defined as a structured representation of the functions, activities or processes within the modeled system.
$IDEF_1$	Deployed to produce a "Data Model" that can be defined as structure and semantics of information within the modeled system or subject area.
$IDEF_2$	Implemented to produce a "Dynamics Model" which represents the time-varying behavioural characteristics of the modeled system.
$IDEF_3$	Process Capture Method.
$IDEF_4$	Object-Oriented Design Method.
$IDEF_5$	Ontology Description.

2.3.5.2 The $IDEF_0$ Modelling Approach

$IDEF_0$ (Integration DEFinition language $_0$) can be described as a business modelling technique that represents a system as a network of inter-connected activities. A mix of graphics and natural language are both used to capture and communicate process details for the objective of capturing a very rich set of process knowledge. In addition to the definition of the $IDEF_0$ language, the $IDEF_0$ methodology also prescribes procedures and methodologies for developing and interpreting models, including ones for data gathering, diagram construction, review cycles and documentation. The $IDEF_0$ is based on structured analysis and design technique. That includes both a definition of a graphical modelling language (syntax and semantics) and a description of a comprehensive methodology for developing models.

Models of the $IDEF_0$ are considered hierarchical and they start with a single activity at the highest level where this activity is then decomposed into three to six activities on the next page. Those activities will be then decomposed if necessary for the purpose of the model. The hierarchical structure means that each page of the model contains a relatively small amount of information. This is a contrast to flow charts that can have many different activities.

The $IDEF_0$ is a public domain modelling system and it is an American Federal Information Processing Standards Publication (FIPS 183), where it can be used to produce structured documentation suitable for ISO 9000 [Draft Federal Information Processing Standards Publication 183, 1993; ElMaraghy, W., 2000 (a); ElMaraghy, W., 2003 (b)].

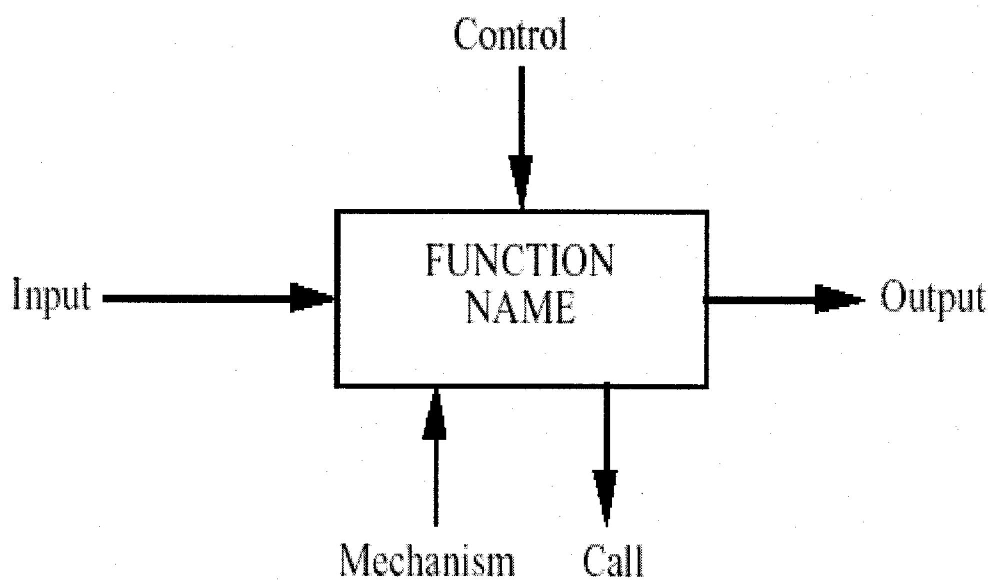


Figure 2.12: The $IDEF_0$ Main Parent Activity Component
[Draft Federal Information Processing Standards Publication 183, 1993]

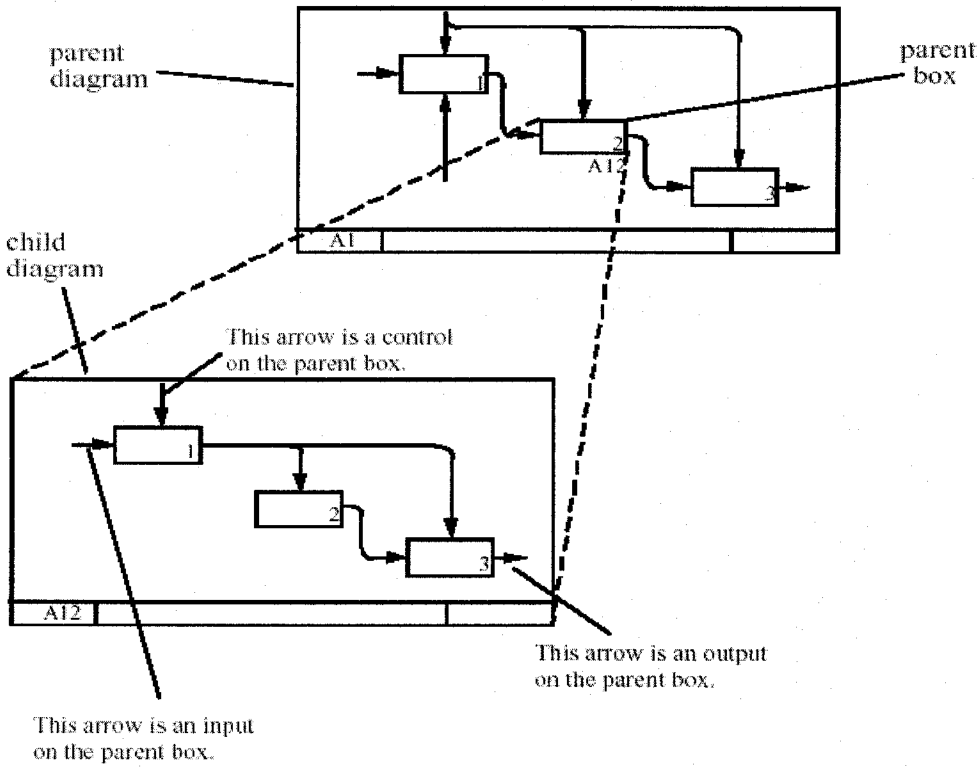


Figure 2.13: The IDEF$_0$ Component And Activity Models [Draft Federal Information Processing Standards Publication 183, 1993]

This concept is considered to be graphical representations of the interfaces between activities that occur in the real world where they are distinguished by their four basic uses on an activity:

1. **Inputs:** information or objects required to perform the activity;
2. **Outputs:** information or objects that are created when the function is performed;
3. **Controls:** the conditions or circumstances that govern the activity's performance;
4. **Mechanism:** the persons or devices that carry out the activity.

The IDEF$_0$ models components as illustrated in Figure 2.12 and Figure 2.13; are considered to be easy to be understood. This is because this methodology only contains two elements - boxes and arrows where the boxes represent the activities and the arrows represent the inputs, outputs, controls and mechanisms of those activities. The inputs are transformed in the activity using, but not consuming, mechanisms or resources such as staff and machines to produce outputs. Moreover, processes and operations of the activity will be moderated by controls such as policies and procedures [Leong, 2000].

The $IDEF_0$ modelling technique can be implemented in data processing and manufacturing systems where these systems consist of a network of inter-connected activities. In addition, the $IDEF_0$ can be used to model a wide variety of automated and non-automated systems. For new systems, $IDEF_0$ may be used first to define the requirements and specify the functions, and then to design an implementation that meets the requirements and performs the functions. For existing systems, $IDEF_0$ can be used to analyze the functions the system performs and to record the mechanisms (means) by which these are done.

The result of applying $IDEF_0$ to a system is a model composed of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. As mentioned earlier, the two primary modelling components are functions that are represented on a diagram by boxes and the data and objects that inter-relate those functions that are represented by arrows and boxes as illustrated in Figure 2.12 and Figure 2.13.

Potentially, the $IDEF_0$ can provide systems engineering approach to performing the SAD at all levels, for systems composed of people, machines, materials, computers and information of all varieties - the entire enterprise, a system, or a subject area.

Also, it produces reference documentation, which is concurrent with the development to serve as a basis for integrating new systems or improving existing systems. In addition, the methodologies can easily increase the communication level among analysts, designers, users, and managers. This is to successfully managing large and complex projects using qualitative measures of progress and supplying reference architecture for enterprise analysis, information engineering and resource management [Leong, 2000; ElMaraghy, 2000 (a); ElMaraghy, 2003 (b)].

2.3.5.3 Characteristics Of The $IDEF_0$ Function Modelling Language

The $IDEF_0$ function modelling language can be considered as a comprehensive, expressive, and capable of graphically representing a wide variety of business, manufacturing and other types of enterprise operations to any level of detail.

Also, the $IDEF_0$ technique assists to improve the communication level between systems analysts/ developers and also the users through ease of learning since it is created on hierarchical exposition of detail. Moreover, the $IDEF_0$ design methodology can be considered as a simple modelling language providing precise expression, and promotes consistency of usage and interpretation. This technique can be generated by variety of computer graphics tools and successfully many commercial products do support development and analysis of its contents [KBSI, 2000; BIS, 2004].

The $IDEF_0$ can achieve four kinds of modelling integration:

1. It is considered to be an integrated modelling approach in which the different modelling processes share same common information on functionality of the enterprise system being modeled.
    a. Ensure compatibility between function model and other models;
    b. Reduce time and effort needed to build and maintain them.

2. It allows system users/ developers to work together more easily than when using models built independently.

3. The use of a knowledge-based system to semi automate the generation of $IDEF_0$ models based on the concept of reference models
    a. Reducing modelling time and effort;
    b. Eliminate model inconsistency;

c. Changing relevant parts of the extended $IDEF_0$ model where that will be much easier to perform than changing directly the controller software can effect any changes to the system operations.

4. Extend the $IDEF_0$ model to include other details (Computer process-able) not only for workflow analysis (e.g. Simulation), but also workflow execution
   a. Reducing time and effort of both system development and system maintenance;
   b. Any changes to system operations can be effected by changing relevant parts of extended $IDEF_0$ model which is much easier than changing directly the controller software.

2.3.5.4 Selected Tool For $IDEF_0$ Modelling Approach

The parent activity namely "A0 activity" is used to establish the context of the model. The diagram including the A0 activity and its activations of the inputs, controls, and mechanism, are used by the activity to produce the activity's outputs where that is referred to as the top level or the A-0 diagram. In addition, the A-0 diagram represents the system that it produces in accordance according to the inputs, controls, and mechanisms depicted.

The "AI0WIN7 model window" provides a graphic representation of each diagram in the active model. It also provides an individual diagram representing the activities as boxes and concepts as arrowed lines. The basic definition of the $IDEF_0$ has been compiled in the AI0WIN7 where the A-0 diagram can contain only one activity where it can be decomposed. However, the decomposed diagrams must contain only 3 to 6 activities as illustrated in Figure 2.13.

In addition, the activity/ concept matrix window illustrates diagrams in a matrix format. Each of the concepts in the diagram listed across the top of the matrix and also the activities in the active diagram are listed to the left as illustrated in Figure 2.14.

The cells of the matrix identify the concept type and the correspondence between activities and concepts in the diagram. The source matrix window illustrates the associations between sources and activities in the active diagram. Where all the sources in the project are listed horizontally across the top of the matrix, the activities in the active diagram are listed vertically at the left side of the matrix [KBSI, 2002].

The main advantage of the model-level windows is the capability of defining occurrences of activities when they are specified to the context established by the model. The user can attach concepts to activities in each of the windows and edit the description, notes, sources, properties and costing information associated with a specified element.

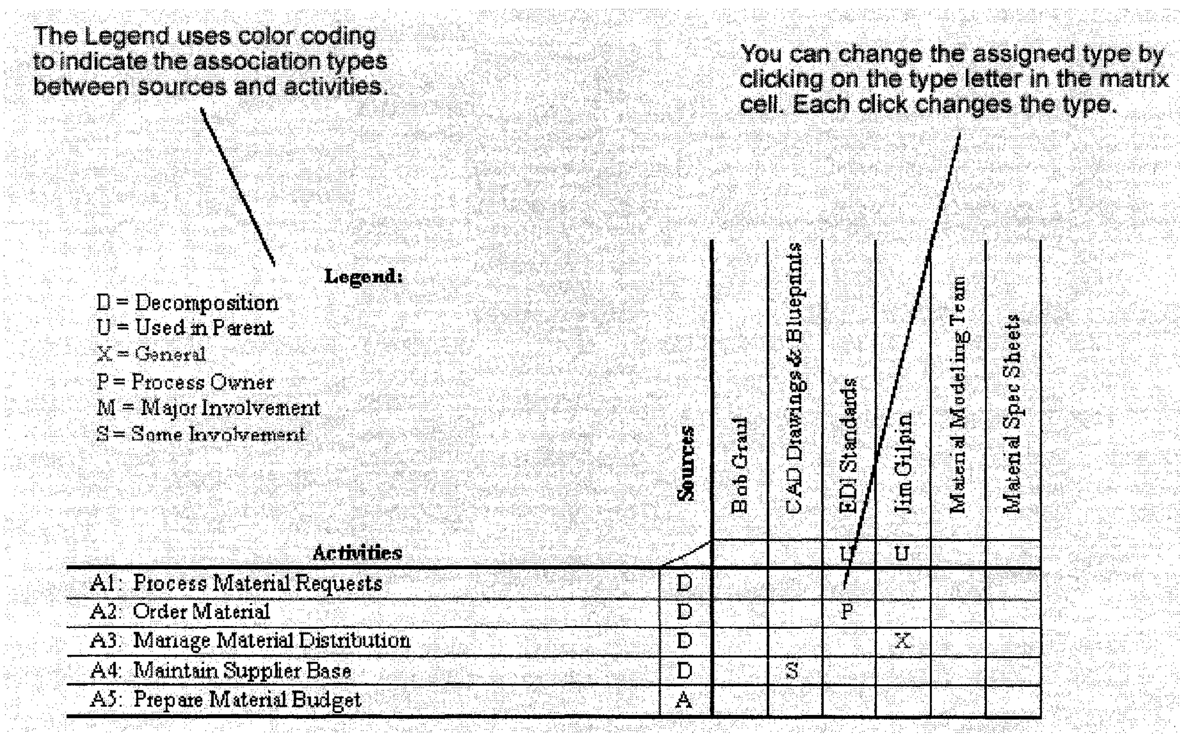


Figure 2.14: The AI0WIN7 Activity/Concept Matrix Window [KBSI, 2002]

The A-0 diagram model represented in the AI0WIN7 tool is organized from the A-0 diagram down, with a succession of diagram levels delivering more detailed information about the A-0 diagram. The levels are numbered, in sequence as A0, A1, A11, A111, and so on.

As mentioned earlier, the A-0 diagram contains a single activity namely, the A0 activity. Its descriptive title is general enough to cover the different levels of sub activities that comprise it. System concepts can be considered as concepts attached to the A0 activity where the uses on the A0 activity define the context of the concept uses in the decomposition diagram.

When an activity is decomposed, the concepts attached to the A0 activity will appear in the decomposition diagram. That will allow the tool's user to distinguish the different sets of activations depicted in the model-level diagram. This is obtained by attaching these concepts to the newly added sub-activities. If the user will attach a concept from the parent-level diagram to an activity in the child-level diagram, the attached concept can be considered as a migrated one.

In the diagram window illustrated in Figure 2.15, the activities are shown in a tiered, descending order from left to right. The activities are numbered according to this order, and the default numbering scheme identifies the diagram level. For instance, the top most activity in the first-level decomposition diagram is numbered as "A1," where in the second-level decomposition is numbered as "A11".

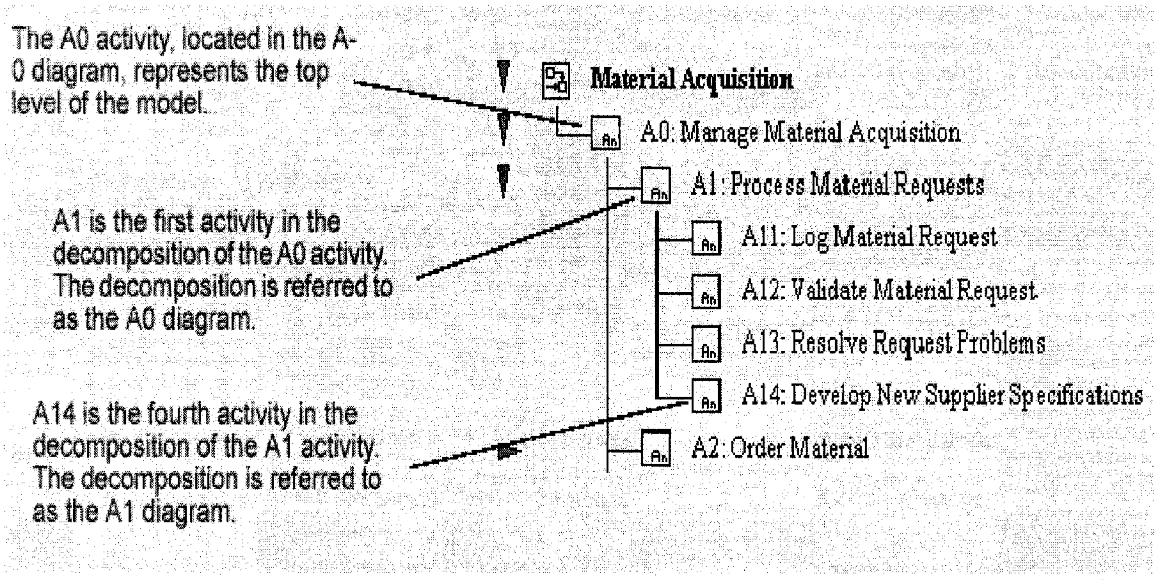


Figure 2.15: Creating Diagram Hierarchies In The AI0WIN7 Tool [KBSI, 2002]

The concepts in the AI0WIN7 tool are shown as lines with arrows where they are labeled, and coded according to their use in the parent diagram. The inputs and outputs are numbered in descending order, and the controls and mechanisms are numbered from left to right. [KBSI, 2002]

This brief description of the AI0WIN07 is compliant with the contents of the $IDEF_0$ processes modelling approach. Such implementation will be illustrated as representations of the tool because of the interest of justifying the tool's capability (and Detect its Deficiencies) through representing two processes' modelling case studies to be presented in this thesis. The representation will be compared with other representation formats including the Microsoft Power Point as well as the other selected BPM methodologies including the ADONIOS, LOVEM in ADONIS, as well as the ARIS framework.

2.3.6 Line Of Visibility Enterprise Modelling

2.3.6.1 Introduction

The LOVEM technique can be described as a graphical design approach for the business process and workflow design or redesign. This approach uses an integrated set of graphical modelling methodologies that helps in analysing and redesigning interactions between business, customers and internal processes. It also assists to develop requirements for customer and employee (Oriented Automated System) [IBM Global Services, 2000].

Moreover, the LOVEM technique can be also considered as a structured methodology for the business BPM*, and Business Process Mapping and Analysis (BPMA), and work flow redesign. The LOVEM has been developed to assist systems analysts and developers in analyzing and designing the organization, the workflows. Also, it is a designed modelling technique to analyze, and design business employees' requirements, and planning skills for the organization [IBM Global Services, 2000].

This modelling technique classifies its needs and wants based on the organizations' customers, employees, as well as the organizations' needs and wants resulting in improving the business processes and satisfying the business customers, employees and business as well. This is illustrated in Figure 2.16 below:

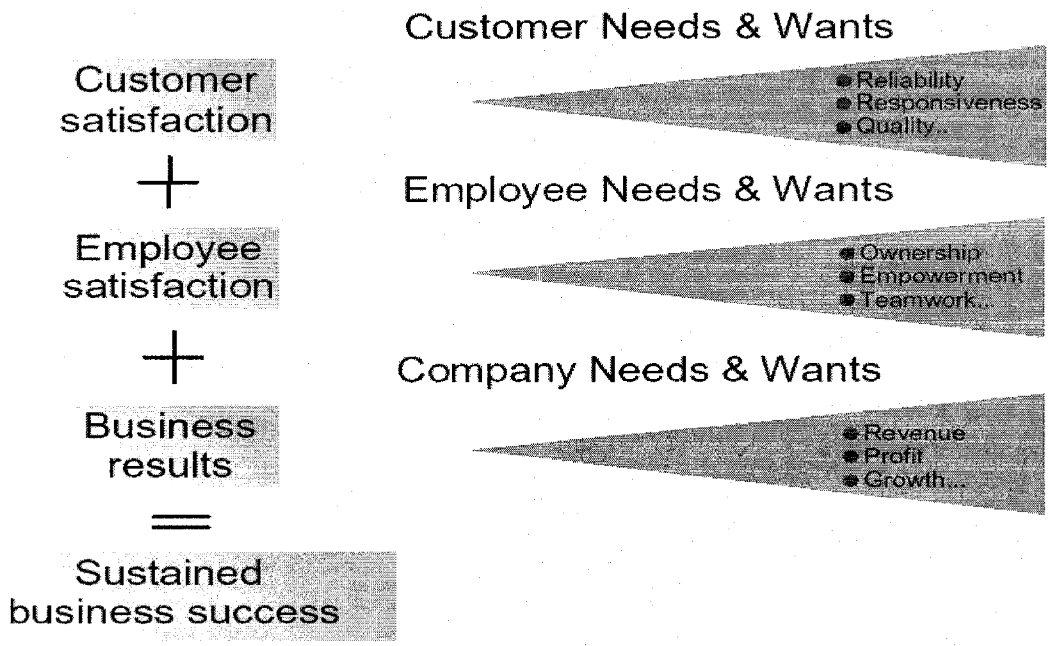


Figure 2.16: Line Of Visibility Needs And Wants [IBM Global Services, 2000]

This customer-business processes approach, a focus on what the customer wants by how he/ she wants since customer satisfaction is considered to be as a high level priority. In addition, its graphical language is considered to be easy to be understood and also it allows working with many other methods and approaches including:

- TQM;
- Information Engineering;
- Strategic Planning;
- Data Modelling;
- Knowledge Management;

- Organizational Analysis and Design; and
- SAD.

Business developers can benefit for working with LOVEM in so many aspects. It can potentially improve the business productivity, and increase customers' satisfaction. Also, it assists in increasing employees' empowerment and enhancing the organizational effectiveness. This is together with improving the processes' quality resulting in improving customer satisfaction.

Moreover, implementing the LOVEM technique can assist in reducing process defects, redundancies, and delays in the process. This will successfully lead to higher customer-employee satisfaction and assist in gaining better understanding of the business processes. In addition, that will result with better internal and external communication and process management, and clearer systems requirements leading to better application systems.

The LOVEM uses specific design language where its terms are described in Table 2.4 as follows:

Table 2.4: Design Language Of The Line Of Visibility Enterprise Modelling [IBM Global Services, 2000]

Objective	Implementations
To Analyze	The AS IS blueprints for problems and opportunities
To Model	Alternatives to a process path at different levels of detail with various design points
To Design	Certain aspects of a business based on a stable model

Table 2.4: Design Language Of The Line Of Visibility Enterprise Modelling [IBM Global Services, 2000] (Continue)	
To Blueprint Business Processes	Either at "AS-IS" or "To Be" state at various levels of abstraction and detail.

2.3.6.2 Modelling Approach

The LOVEM methodology uses the workflow charting to support workflow analysis and re-engineering. The LOVEM in ADONIS as illustrated in Figure 2.17, will be used as a tool to help using LOVEM methodology towards selected processes modelling implementations in this thesis work.

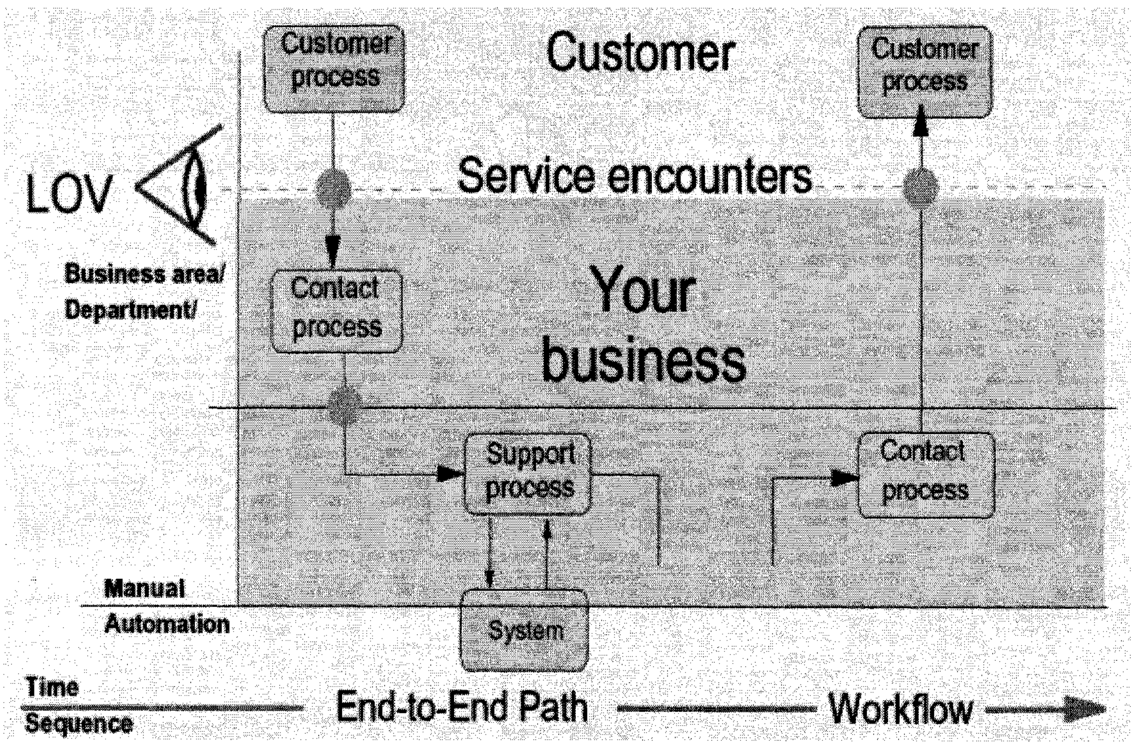


Figure 2.17: Line Of Visibility Graphical Process Modelling Chart [IBM Global Services, 2000]

As mentioned earlier, the process capability of the LOVEM can be described in enabling systems developers to use other methods and approaches with it. That includes information engineering, data modelling, knowledge management, and also the SAD methodologies [IBM Global Services, 2000; Trautmann, 2000]. The Line of Visibility Charts (LOVC) uses the “AS-IS” and “TO-BE” business process designs at the logical, physical, and also the job levels.

The Logical LVC (LLOVC) presents a high-level view of the processes and data for one line of business or business area. They assist in defining and documenting in context all business rules and policies. That includes the Critical Measurement Point (CMP), Critical Success Factors (CSF), and also the Goal Strategy Policy (GSP). In addition, the LLOVC can also be deployed for process path management since it is considered as stable model. That provides a high level scope of work beside the fact of being a common specification language. The main focus of the LLOVC is on the “What-To-Achieve” for one LOB including customers’ band, LOV, business area, customer processes, internal processes, business control, and also the data flows [IBM Global Services, 2000].

The Physical LOVCs are detailed blueprints of the departments, jobs, systems, activities, information flows, and also measurements. They illustrate the interactions between internal, external, and customer organizations. The “AS-IS PLOVCs” are deployed to assist discovering Problem Areas (PAs), and CMPs for the aim of developing some useful solutions. The “TO-BE PLOVCs” represents the reengineered processes, organization, and systems.

While working on a BPR project, the PLOVC can assist in understand the “AS-IS” and also the TO-BE process design at the physical levels. It also facilitates the organizational analysis and design and assists in preparing the workflow implementation where it also can be implemented for communication, and education. Moreover, the PLOVC can be used as a blueprint for business decisions. Such use will result in preparing the outsourcing, restructuring the process flow, and enabling in introducing new technology and systems.

Improving the cycle time and lowering the operational costs are also achieved while deploying the PLOVC. It assists business analysts and developers to successfully determine areas required for of reengineering. In addition, it supports Day-To-Day senior level management's decisions. The main focus of the PLOVC relies on how one objective can be achieved. Such objective might include customer band, customer activities, information flow, LOV, and department/ job bands [IBM Global Services, 2000, Trautmann, 2000].

According to IBM [2000], the most detailed view of the business processes can be achieved by deploying the Job Line of Visibility Charts (JLOVCs). They assist in providing accurate blueprints for each job, showing interfaces to customers, internal and external organizations, as well as systems. Also, the JLOVC assists in understanding the individual job where that is considered as a final step in the top down design. It can be considered as a framework to determine the skills, education and hiring requirements, staffing levels, Job levels, and direction the business should follow in the future. As of assisting the business communication and education, the JLOVC can assist in selecting new employees, internal and external interfaces and also enabling process and business implementation.

2.3.6.3 ADONIS Business Process Management Toolkit

ADONIS is a multi-user, client-server toolkit for the Windows environments. It is intended for the modelling of the activity based organizational processes, used for a large variety of different modelling purposes. The (IS) is stored in relational databases, namely Oracle, and MS Structured Query Language (SQL) server. Moreover, information maintained within the ADONIS system can be easily accessed via an open interface using ADONIS Definition Language (ADL) or Extensible Mark-up Language (XML) [BOC, 2004, Boucher et al., 2003].

The ADONIS application might be described in different scenarios as follows:

- Business process optimization and continuous improvement of the business processes (Benchmarking, Monitoring, "AS-IS" Vs. should-be scenarios);
- Organisation management (Organisation documentation, Job descriptions);
- Controlling (Process Costing, Activity Based Costing (ABC);
- Process-based knowledge management;
- Process-based development of E-business applications;
- Personnel capacity planning;
- Strategy management;
- Skills management; and
- IT management.

It includes a graphical modelling editor to visualize the enterprise business processes system (workflow, methods). It also includes organisational environment (company organisation, IT systems). According to BOC [2004], the analysis component within the ADONIS BPM* tool is based on a query language, which is able to refine all kinds of model and process information. The results can be displayed in graphical or tabular format. It can also be exported to a vast group of other tools in various formats.

Simulation component assists in investigating impact and effects of changes in the business processes or the organisational structure before implementing physically implementing them. The ADONIS tool includes different simulation algorithms, used in static or dynamic personnel and resource planning. Similarly, results can be displayed in graphical or tabular format, and exported to other tools. It is vital to add here that the LOVEM in ADONIS tool kit offers more than just one standard configuration. In addition, the extensive customising capabilities enable system developers to configure the meta-concept of ADONIS to meet precise requirements.

The ADONIS BPM* tool kit has been mainly implemented focusing on its standard SAD approach as well as on the LOVEM component embedded in this tool. In addition, both cases studies in this thesis have been represented through the ADONIS standard processes modelling types. This has been demonstrated in both Appendix C. as well as Appendix D. the implementation of the LOVEM component in ADONIS tool kit has been also included in this thesis. In addition, the installation procedure of the LOVEM in ADONIS has been presented in Appendix F [BOC ITC GmbH, URL: www.boc-eu.com].

2.3.7 Architecture Of Integrated Information System

2.3.7.1 Business Process Framework

BPR can be considered as a key issue for enterprises to regain competitiveness and profitability in increasingly unstable market. Enterprises that are customer-focused need to be structured along their core processes, and have to be strictly value-oriented. Moreover, the workflow management is based on cooperative, distributed workflow applications. It requires business process re-engineering to be effective, and also considers process models as a specification for the control of the process execution.

The focus of the architecture of integrated information system (ARIS) targets the analysis and requirements definition phases during the design of managerial IS. The ARIS can be considered as a multi layer – multi view approach. Its main focus relies on the business-related issues distinguishing between the organization, function, information and control views as illustrated in Figure 2.18. Each view can further be detailed according to suitable methods with a condition of being compatible to the contents of the ARIS framework.

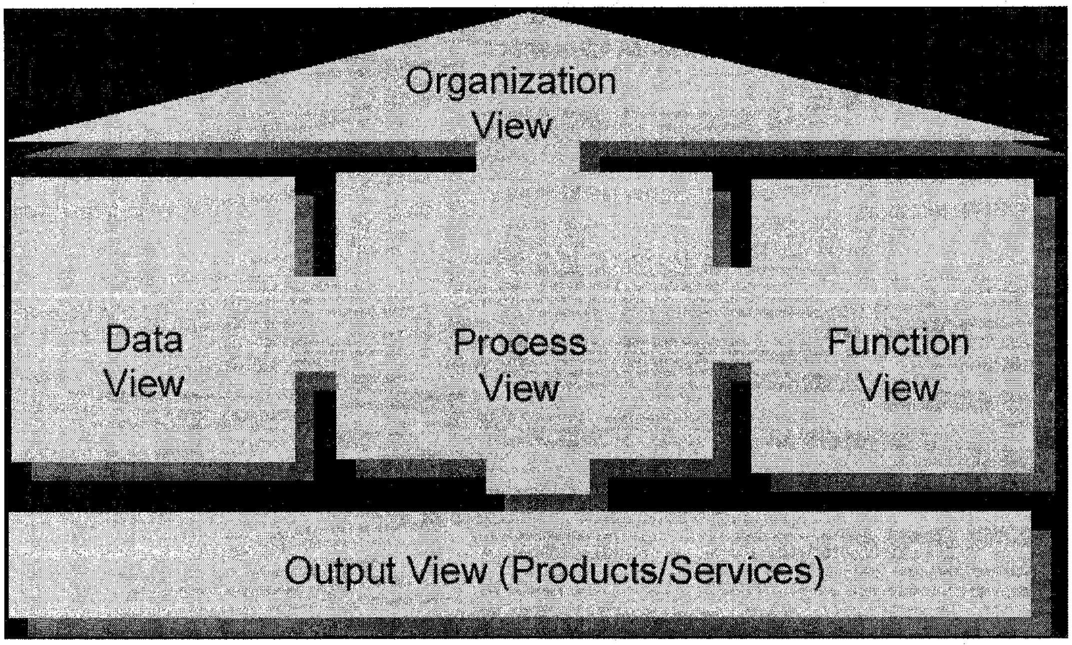


Figure 2.18: ARIS Business Process Framework View [Hammer, 2003]

The ARIS approach provides a generic well documented methodological framework as well as a powerful BPM tool. It assists in supporting the entire process re-engineering project during all life cycle phases.

The most important entities here are functions and events, which are linked together to the Event Driven Process Chain (EDPC). The EDPC models the control flow of the business process. It can be extended by links to other relevant entities contributed by other views. Functions can be connected to input and output data, which are located in the data view to model the data.

The ARIS-BPM approach can be considered as a basis for developing the business view. This is because the ARIS has an elaborated decomposition of an enterprise in several views including data view, function view, and organization view. This is to realize the connection between these views defined as the control/ process view.

Also, ARIS integrates several modelling methods, for example, the entity relationship models, and object-oriented approaches. More and more, ARIS is supported by a toolset, which is commercially successful and implemented in several industrial applications as mentioned earlier [IDS-Scheer, 2003; Hammer, 2003].

The ARIS business process framework is a unique and internationally renowned method for optimizing business processes and implementing application systems. The ARIS methods can successfully model and realize business processes. This will successfully lead to an information model that is the keystone for a systematic and intelligent method of developing application systems. Such application system is developed for BPI whatever or wherever they are in the enterprise. This is an acknowledged way of improving the enterprise business processes [IDS-Scheer, 2003; Hammer, 2003].

2.3.7.2 Business Process Architecture

As described in previous section, the ARIS business process framework is based on four different views for capturing and documenting the enterprise business processes. They are described in three layers of abstraction that will be discussed and illustrated in this section. As illustrated in Figure 2.19, the planned innovation and underlying application system architecture are defined. Then, information is forwarded to process specification layer, where using methodologies like simulation' specifies blueprint for the resulting business processes, best practice reference.

The ABC models are used as a guideline for implementation of all physical and information handling processes on execution layer. This is done within and across enterprises IS based on standard application software package. The individual business process execution engines are based on the business process specification [Scheer, 1992; Hammer, 2003].

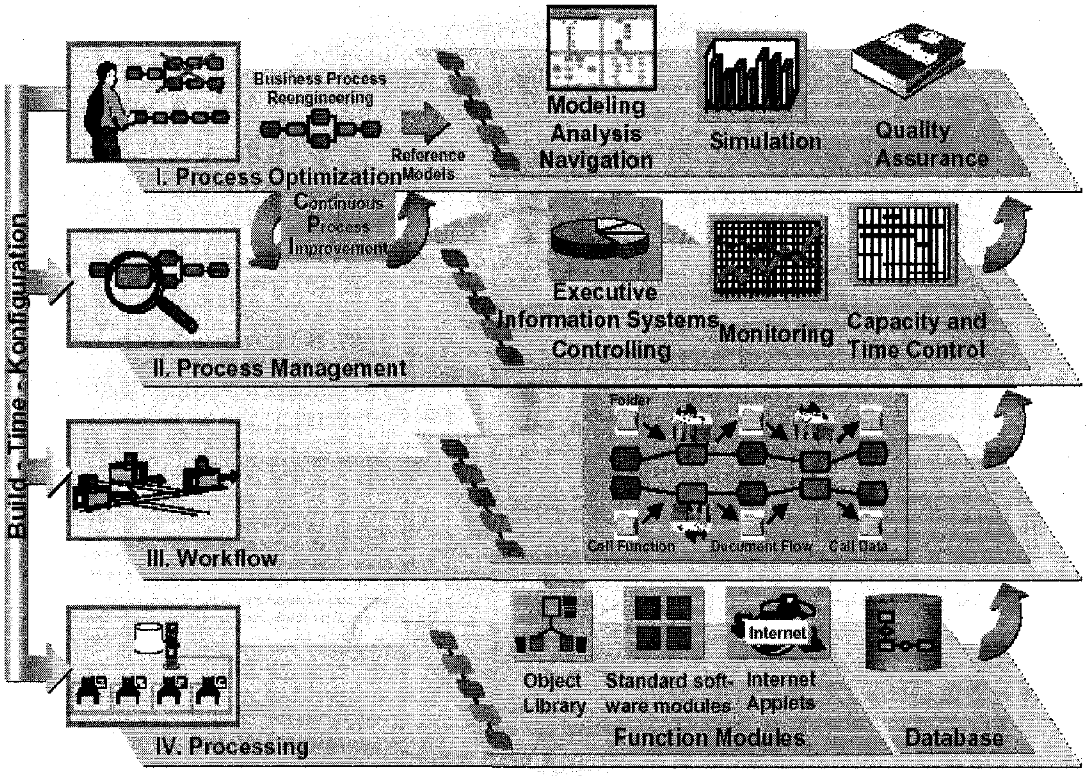


Figure **2.19: ARIS Business Process Architecture View [Hammer, 2003]**

Next, the executed processes are measured and controlled on the controlling level. If differences observed between planned key performance indicators and the actual values, either a CPI will be done through the process specifications layer or the situation is resolved on a strategic level. The ARIS requirements definition follows primary business oriented and not technical goals. For instance, during the requirements definition, aspects such as time, costs, frequency, redundancy, etc., are explored. After conducting initial level business processes analyses, alternatives for BPI are developed next. That will mainly rely on what kind of solutions is considered to achieve the chosen alternative based on the interest. It could be organizational, personal, technical, or even a mixture approaches.

From the technical point of view, it is possible to explore BPM with regard to what kind of (IS) is necessary. Therefore, all views have to be integrated in the process model. That must include information, organization, function, and processes as described earlier in the RAIS framework view earlier. The processes modelling is defined on the requirements definition level and approved as input for the development of workflow applications, where they can be refined in the next level. The ARIS-BPM approach covers a comprehensive view of the entire business. This is because it has an elaborated decomposition of the enterprise in its data view, function view, and also organization view. Also, it assists in determining the connection between these views, (the control/ processes view).

2.3.7.3 Architecture Of Integrated Information System and Zachman Framework – A comparison

A detailed description of the Zachman and ARIS frameworks has been presented in this thesis. In this section, a summary of both frameworks will be presented where that will be followed by a comparison of both frameworks. As described earlier, the Zachman framework is viewed as a matrix where the stakeholders involved in the architecture design process (Planner, Owner, Designer, Builder, Subcontractor, and User) are represented on the vertical axis. On the horizontal axis, abstract description fields show what, how, and where will be produced by whom, when and why. The vertical perspectives of the framework are components from high level to detailed components following the software development lifecycle.

The Zachman framework outlines appropriate methods to capture and analyze the coordination and integration needs at each intersection of a vertical and horizontal component. The framework presents one of the most comprehensive attempts to ensure that all aspects of a planned business system are properly captured and modeled. The two-dimensional framework in the Zachman framework can be considered as "easy to understand". In addition, they are accepted and applied by many organizations worldwide [Schallert, 2001].

However, the Zachman framework has some shortcomings through the missing explicit integration between the different horizontal dimensions in the framework. Schallert [2001] stated that the "Zachman Framework does not directly emphasise value creation within processes. Therefore it is not explicitly oriented on outputs, business processes and overall efficiency".

The ARIS is considered to be concepts similar to the Zachman framework. It has five different perspectives, which cover different viewpoints on an organization (Business Processes, Functions, Data, Organizational Structure, and Outputs). Moreover, three different levels represent the main stages of the software engineering lifecycle. They are the requirements definition, design specification, and implementation.

The resulting two-dimensional ARIS framework concentrates on business processes, unlike the Zachman framework where all perspectives are equally related to each other. A more process-oriented view is taken across the organization, providing the basis for the integration of all elements in enterprise architecture.

The principal objective of both approaches is to integrate IS, and to bridge the gap between strategy and implementation. The ARIS and Zachman frameworks have a similar design paradigm as they both span a two-dimensional framework.

However, the six vertical dimensions (Description Fields) in Zachman's approach are similar to the views in ARIS, both approaches split the complexity of an organization into the same perspectives; what, how, where, who, when and why. Moreover, the Zachman six horizontal representation perspectives are analogous to the implied software lifecycle concept in ARIS [Schallert, 2001].

In the following part, it will be outlined in details how the ARIS approach can contribute to overcome these shortcomings while still following the Zachman Framework structure.

2.3.7.3.1 Vertical Comparisons

The main strength of the Zachman framework is a detailed focus on description fields. It distinguishes between data, function, network, people, time and rationale. ARIS is primarily focused on business processes, data, functions and organization.

As illustrated in Figure 2.20, data and functions correspond directly with the Zachman framework. The organization view in ARIS captures both, people and network on different levels of abstraction. This simplifies the enterprise architecture of an organization. The time component of Zachman's framework is implicitly part of the data view in ARIS. This is because the modelling object 'event' represents stages of business objects in terms of time and logical sequence.

Furthermore, objective diagrams as part of the function view in ARIS cover Zachman's description field of 'rationale'. Thus, in a business framework all rationales can be captured. In conclusion all vertical description fields of the Zachman Framework can be found in ARIS' views. Figure 4 summarizes the determined commonalities of the Zachman Framework and ARIS.

The four main ARIS views (Data, Organization, Function, and Process) ensure that enterprise architectures can be captured in its completeness and from various perspectives. That includes business, application, information, and technology.

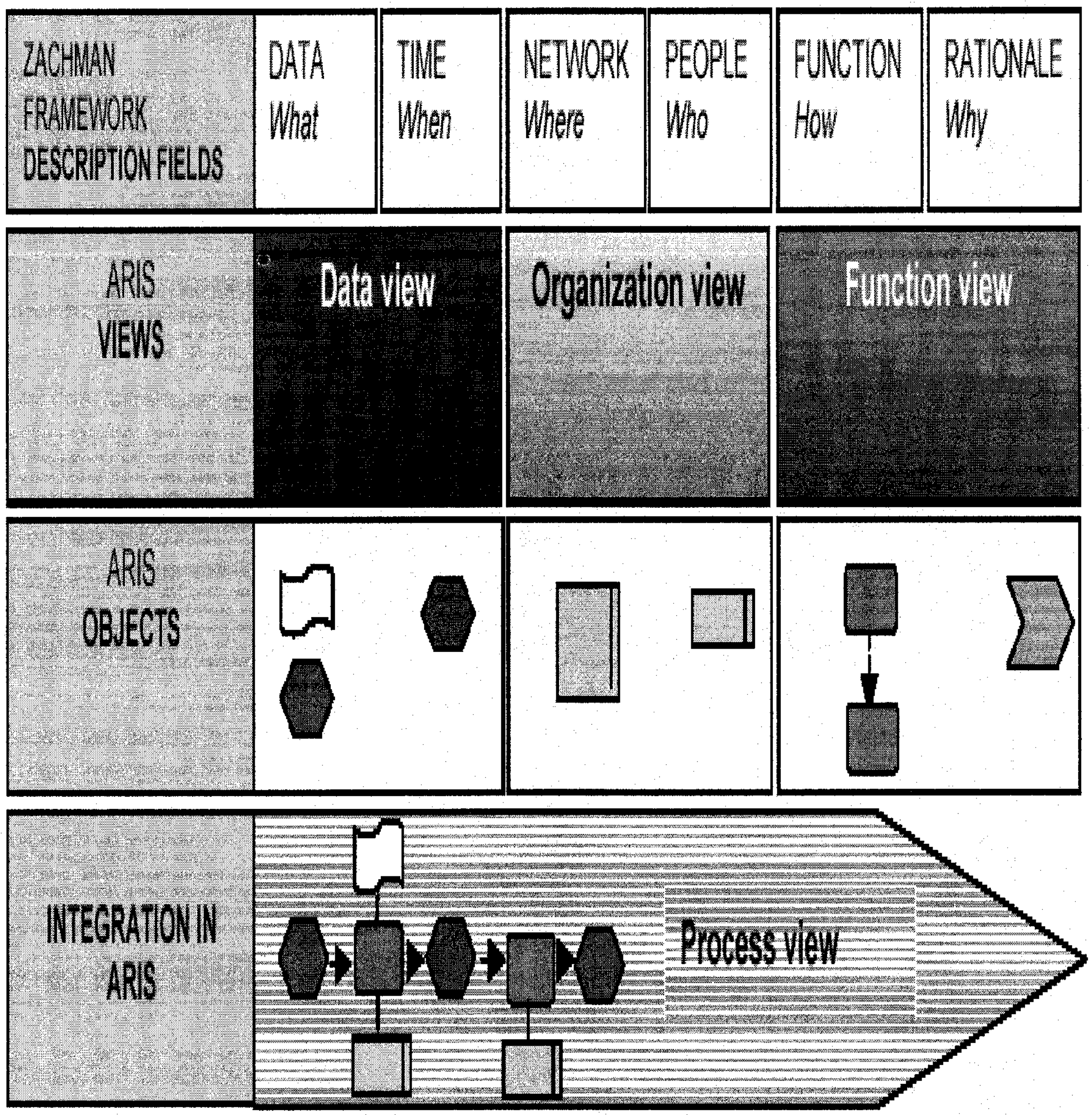


Figure 2.20: Vertical Comparisons And Integration In ARIS [Schallert, 2001]

According to Schallert [2001], "ARIS is complemented by an output view emphasizing the importance of value creation within an organization on all levels. Also, it includes the integrative and dynamic process view". This leads to a high level of consistency of the enterprise architecture. In comparisons to the Zachman framework, this additional focus on business processes is a particular advantage, especially when integration of IS will be the declared objective.

2.3.7.3.2 Horizontal Comparisons

Design paradigm of the ARIS and the Zachman frameworks, follows the main idea of integration of IS. Both frameworks address the organization in their entireties, coordination, and integration needs. Also, they are based on predefined levels of abstraction to simplify, reduce, and manage complexity.

The implementation of a lifecycle concept for IS in ARIS is similar with the six perspectives within the architecture design process of Zachman's framework as illustrated in Figure 2.21. The design process addresses all completed tasks of enterprise architectures for all involved stakeholders. That includes the planner, owner, designer, builder, subcontractor, and user. In addition, the planner's contextual level who defines scope and objectives in the Zachman framework is similar to the description of a business problem in ARIS.

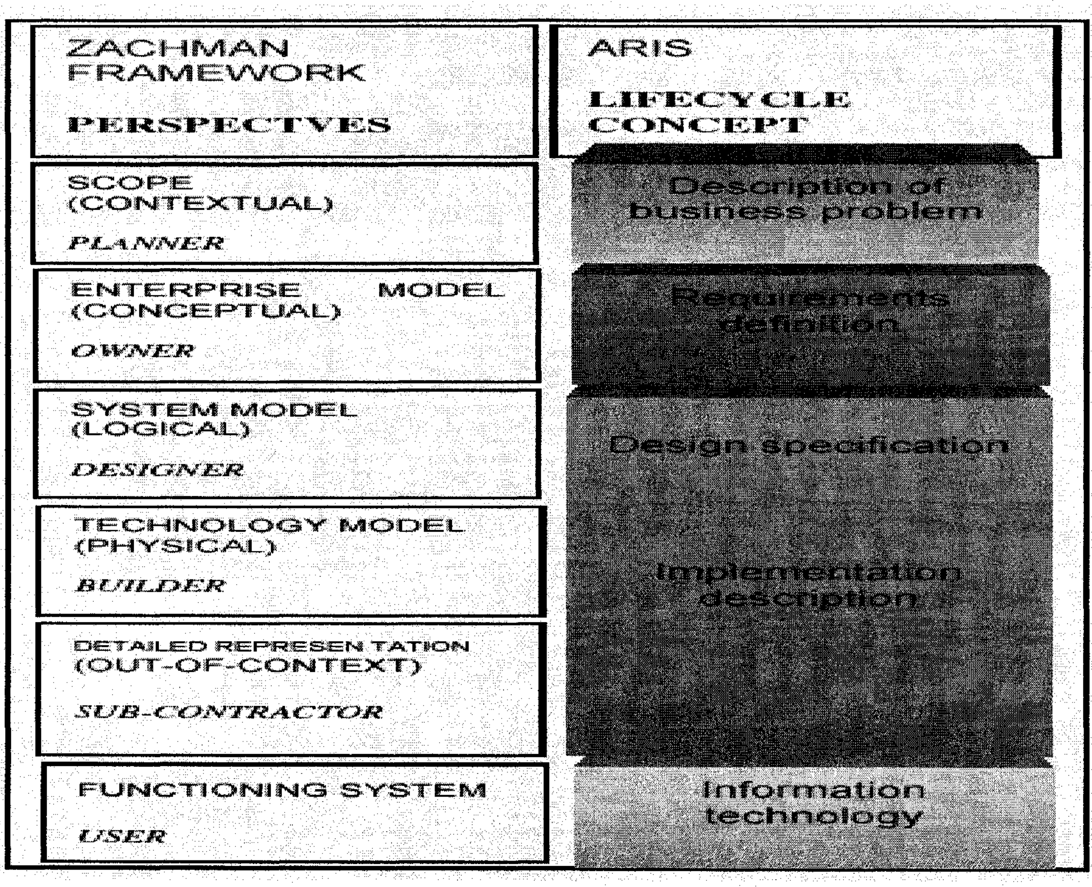


Figure 2.21: Horizontal Comparisons And Integration In ARIS [Schallert, 2001]

Both frameworks focus on establishing a concept, which describes the required functionality of the IS. In the lifecycle concept of ARIS, the design specification and implementation description' describe the logical, physical, and out of context perspectives of the Zachman framework. The ARIS framework summarizes these three different levels into only two, neglecting the "Out of Context" level.

Schallert [2001] believes that it is "Questionable How Far the Out of Context" level of Zachman's framework adds significant value within the design process. This was originally derived from an industry design process for airplanes, where subcontractors play a significant role. Furthermore, it could be concluded that the subcontractors are only substitutes for designer and builder and are not related to specific tasks as designer and builder are. However, continues interaction between designer, builder and subcontractor means that that the IS will be designed and finally implemented".

Functioning system is ensured at the lowest level, which is similar to ARIS transcription into the IT. The ARIS design specification is translated into concrete hardware and software components. Both ARIS and Zachman framework can be considered as a map, which covers the complete cycle from strategy to implementation of IS. Such map allows transforming from a strategic to an operational level. The ARIS lifecycle concept for the IS summarizes and simplifies this area while emphasizing on the interrelations of single concept phases [Schallert, 2001].

2.3.7.3.3 Method Comparisons

As the Zachman framework is not designed as a tool-based, ARIS can be regarded as complementing this concept. Based on several integrated modelling methodologies, it is very clear that ARIS can capture a complete picture of data, applications, organizations, and processes supported by a tool set. It comes with an underlying Meta model that precisely specifies interrelation between all modelling methodologies. This is major comparisons that Zachman framework lacks but ARIS has overcome.

However the Zachman framework provides a very popular approach due to its simple and logical structure to build enterprise architecture, the lack of a corresponding tool is its main shortcoming. Table 2.5 illustrates how the selected ARIS modelling methodologies from Table 2.6 below can be utilized within the Zachman Framework.

Table 2.5: Modelling Methodologies In ARIS [Schallert, 2001]

View	Description Level of System Lifecycle	Description Method/ Modelling Technique
Function	Requirements Definition	▪ Function decomposition diagram ▪ Process-oriented function tree ▪ SAP application diagram ▪ Objective diagram
	Design Specification/ Implementation	▪ Application system type diagram ▪ Application system diagram
Data	Requirements Definition	▪ ER model ▪ Data cluster ▪ Technical term model ▪ SAP structured ER model (SERM) ▪ (Semantic) Data model ▪ Material diagram ▪ Data warehouse ▪ Authorisation hierarchy ▪ Cost driver diagram ▪ Information carrier diagram
	Design Specification Implementation	▪ System interface model ▪ Attribute allocation diagram ▪ Data Table diagram
Organization	Requirements Definition	▪ Organizational chart ▪ Role and person type diagram ▪ Location allocation diagram ▪ Shift calender
	Design Specification/ Implementation	▪ Network topology ▪ Network diagram ▪ Technical resource model
Process	Requirements Definition	▪ Business framework ▪ Value added chain ▪ Extended event driven process chain ▪ Function allocation diagram ▪ Information flow diagram ▪ Process chain ▪ Rule diagram ▪ Communication diagram ▪ Input/ Output diagram ▪ SAP ALE models ▪ Business control diagram ▪ E-Business scenario diagram
	Design Specification Implementation	▪ Access diagram ▪ Program structure/ flow chart ▪ Screen diagram ▪ Data flow diagram ▪ Hardware/ software allocation diagram

Table 2.6: Positioning ARIS Modelling Methodologies Into The Zachman Framework [Schallert, 2001]

	Data view		Organization view		Function view	
	DATA *What*	TIME *When*	NETWORK *Where*	PEOPLE *Who*	FUNCTION *How*	MOTIVATION *Why*
SCOPE CONTEXTUAL *Planner*	Business framework					
ENTERPRISE MODEL CONCEPTUAL *Owner*	Semantic data model Data warehouse Material diagram		Organisational chart Location allocation diagram		Function tree Objective diagram	
SYSTEM MODEL LOGICAL *Designer*						
TECHNOLOGY MODEL PHYSICAL *Builder*	System interface model Data table diagram		Network topology Technical resource model		Application system type diagram Application system diagram	
DETAILED REPRESENTATION OUT OF CONTEXT *Sub-Contractor*						
FUNCTIONING ENTERPRISE	data	schedule	network	organization	application	

In summary, both horizontal and vertical dimensions of these approaches capture the same objects. The ARIS main advantage lies in the integrative process view and the support by a market leading modelling solution. A high level blueprint for building enterprise architectures is delivered by the Zachman framework. The ARIS has the capability of capturing the dimensions of Zachman's framework in a very similar way. However, this was included with different naming and grouping.

Finally, a comparison between the ARIS and the Zachman framework has been conducted and illustrated in Table 2.7 below. Such comparison has indicated that ARIS is the perfect complement to facilitate the design of enterprise architectures [Schallert, 2001].

Table 2.7: Comparisons Of The Zachman And ARIS Frameworks [Schallert, 2001]

Criteria	Framework for Enterprise Architecture by John Zachman	Architecture of Integrated Information Systems (ARIS)
▪ Stable consistent methodology	✓	✓
▪ Address the organization in its entirety	✓	✓
▪ Holistic focus	✓	✓
▪ Entity relationship based	✓	✓
▪ Data and process driven	✓	✓
▪ Tool based	✗	✓
▪ Classification scheme	✓	✓
▪ Drill down approach	✓	✓
▪ Two dimensional	✓	✓
▪ Abstraction to reduce complexity	✓	✓
▪ Integration to grasp interrelations	✓	✓
▪ Modelling techniques	✗	✓
▪ Integration of an IS lifecycle	✓	✓
▪ Integrative, dynamic process component	✗	✓
▪ Output and value orientation	✗	✓

2.3.7.4 Business Process Modelling Toolset

With continuous BPM*, systems developers can secure international competitive advantages and also ensure an optimum ROI. That will be achieved by implementing the right business processes analyses, design modelling methodologies, and tools [Scheer, 1992; Burlton, 2001].

The ARIS tool set provides comprehensive computer support for BPM where its module provides means for a Computer Aided Analysis (CAA) planning and introduction of managerial IS. This systematic approach covers the entire Modelling Life Cycle (MLC) as illustrated in Figure 2.22 [Hammer, 2003].

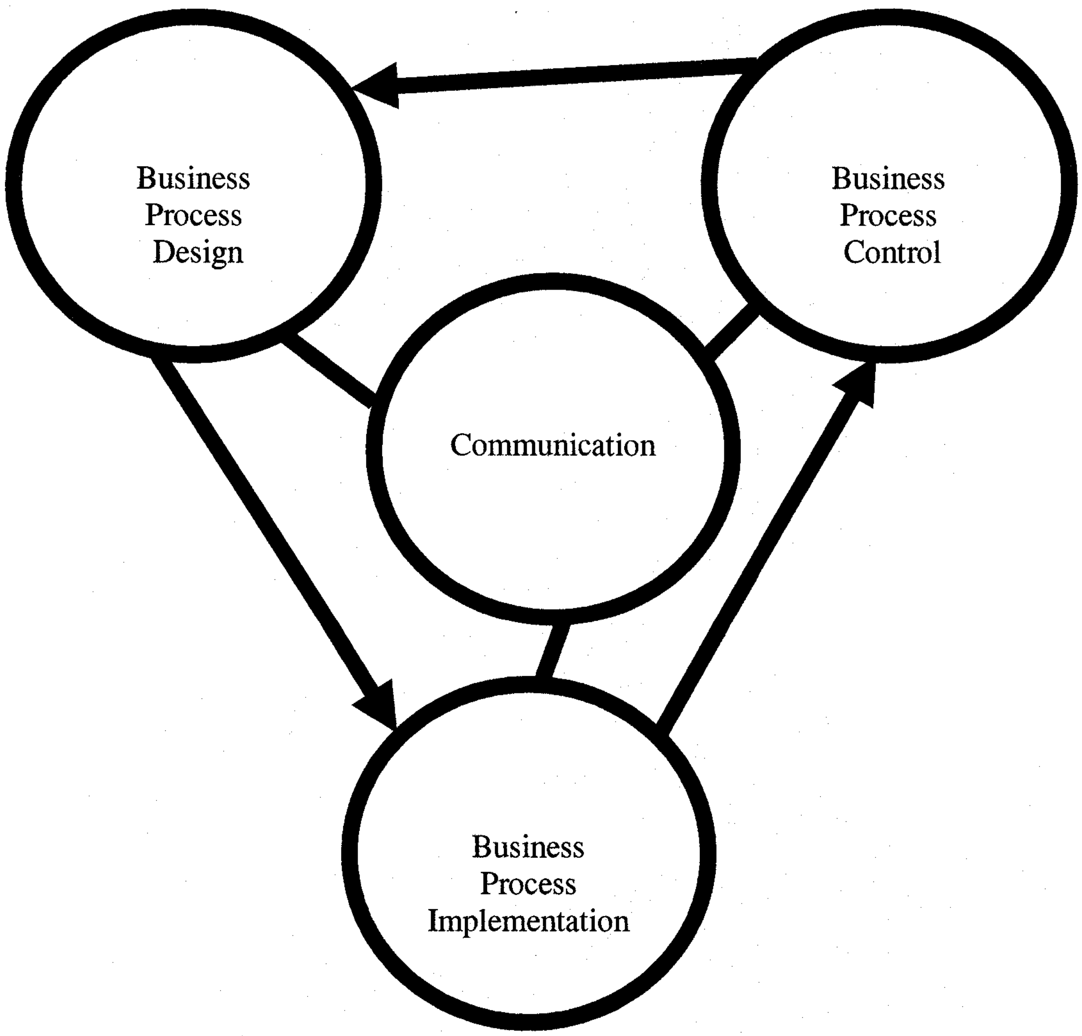


Figure 2.22: ARIS Business Process Life Cycle [Hammer, 2003]

The ARIS toolset provides realistic modelling, simulations of resources utilization, and ABC calculations such as (Make-or-Buy Decisions). Also, it provides a web-based communication of the modelled and optimised company processes. According to Professor Scheer's view on the business processes change management, "Companies must change and they have to do so in ever shorter cycles where the causes are well known including globalisation, competitive pressure, corporate mergers and trends such as e-business, e-commerce, business process optimisation and workflow" [Doppler and Christopher, 2001; Scheer, 2004; ElMaraghy, 2003 (b)].

Systems developers are required to understand "Who does what and in what order? Which services are provided? And which software systems should be used to provide them?" The business models in the ARIS toolset provide users with a stable and proven basis for answering these questions listed above by professor Scheer. Capabilities of the ARIS business process framework lie on examining and assessing the current systems with regard to key performance indices. This is where weak point analysis can be conducted for each modeling [IDS-Scheer, 2004; Rosemann, 2000].

As mentioned earlier when this modelling approach has been discussed, the ARIS business processes framework focuses on the analysis and requirements definition phase during the design of managerial IS, not on the execution of business processes. This comprehensive approach provides a generic and well-documented methodological framework.

ARIS business process framework' illustrated in Figure 2.18 distinguishes between organization, function, information and control views. It uses a graphic modelling system supported by a tool set which models data movement and tasks.

In summary, the ARIS simulation is a professional tool for the dynamic analysis of business processes, fully integrated in the ARIS tool set. Data related to the processes can be used and recorded in the ARIS toolset, as basis for the simulation of business processes. This simulation supplies information about the excitability of processes, and processes weak points [IDS-Scheer, 2004; Rosemann, 2000].

Based on the simulated business processes key performance indicators, system developers can successfully evaluate different alternatives. Also, they can perform a realistic benchmarking where that is before creating any cost-intensive process changes within the business resulting in the functional and organizational hierarchy charts.

2.4 Literature Review Summary

In this section, a summary of the SAD methodologies in addition to the literature survey conducted has been presented. The literature has been classified according to the objective, fields of applications, design methodology and approach. It also focused on type of solutions technique resulted assisting in reducing the complexity of enterprise business processes modelling as summarized in Table 2.8, and Table 2.9 in this section.

The literature has covered all aspects of BPM methodologies and languages implemented to improve enterprise business processes performance and reduce their managerial complexity.

Different modelling languages have been covered in the literature, including UML, which can be defined as a standard modelling language for the specification, visualisation, construction and documentation of software systems artifacts. The UML provides a collection of diagrams, used to model a system from different perspectives. That can be grouped into two categories. Structural diagrams, which are used to visualise, specify, construct, and document the static aspects of a system. In addition, the UML includes four types of structural diagrams: class diagram, object diagram, component diagram, and deployment diagram.

The second category includes the behavioural diagrams. They are used to visualise, specify, construct, and document the dynamic aspects of a system. The UML provides five types of the behavioural diagrams. They include the use case diagram, state chart diagram, activity diagram, sequence diagram, and also the collaboration diagram. A logical picture of a business process can result when various model elements are grouped together. They include inputs, outputs, events, goals, and other important resources.

The CIMOSA has defined four different modelling views function, information, resource, and organisation. This set of views may be extended if needed. It is based on a three stage process-based enterprise modelling approach, partly covering the enterprise life cycle. That includes the requirements definition, design specification, and implementation description. While the sequence of modelling is optional, it may start at any of the life cycle phases and may be iterative as well. That depends on the intention of the model engineering.

$IDEF_0$ can be defined as a business modelling technique that represents a system as a network of inter-connected activities. $IDEF_1$ design language is used for data modelling it is defined as a structure and semantics of data within the modeled system or subject area. It captures conceptual views of the enterprise information. $IDEF_{1X}$ is used for data modelling, which captures the logical view of the enterprise data. It is based on an entity relationship model for logical database.

$IDEF_2$ is deployed to produce a "Dynamics/ Simulation Model", which represents time-varying behavioural characteristics of the modeled system. It is implemented to represent time varying behaviour of resources in a manufacturing system. Various commercial products and notations have replaced it.

In addition to the summarized $IDEF_X$ modelling language, $IDEF_3$ is used for capturing behavioural aspects of a process. It allows different views of how things work within an organization. It consists of two modelling modes: the process flow description, which describes how things actually work in the organization. The second one is the object state transition description. It summarizes an object's allowable transitions in a particular process. It is suitable to model both simple and complex processes due to its decomposition ability. In contrast to $IDEF_0$, $IDEF_3$ has been developed for explicitly describing processes. The former shows what is done within the organization while the latter shows how things work with it. From domain experts, descriptions are captured in which the precedence and causality relationships between activities and events of the process are shown. $IDEF_4$ is an object-oriented design method and $IDEF_5$ is an ontology description method.

Because of the nature of the two processes modelling case studies in this thesis, the literature of the $IDEF_X$ modelling language has targeted $IDEF_0$. It provides a means for communicating and presenting results. It establishes a forum and a structure for data gathering and knowledge acquisition. In addition, the $IDEF_0$ includes identifying opportunities for improvements and revealing data relationships and incongruities. It assists in identifying and categorizing information entities, which form the foundation for information modelling ($IDEF_{1x}$) [Saven, 2003].

As primary justifications for selecting $IDEF_0$ to be implemented instead of the higher $IDEF_X$ modelling language, it assists to produce a structured representation of the functions, activities or processes within the modeled system. The $IDEF_0$ function modelling language can be considered as a comprehensive, expressive. It is also capable of graphically representing a wide variety of business, manufacturing and other types of enterprise operations to any level of detail.

The LOVEM-BPM* language has been covered in the literature. It assists in analyzing and designing the interactions between customers and business internal processes.

The Zachman's framework for enterprise architecture proposes a structured set of perspectives and levels to define and describe complex organizations. It deploys a generic classification scheme to represent a complex object. The output of such a scheme is to focus on single aspects while at the same time taking a holistic perspective. This is mandatory for the management and continuous development of an organization.

ARIS is based on a sound theoretical foundation and follows pragmatic objectives, similar to the Zachman framework. ARIS consists of different perspectives and various abstraction levels. The ARIS-BPM approach can be considered as a unique and internationally renowned method for optimizing business processes. This also includes the successful implementation of application systems. The literature has stated that the ARIS concept provides a full-circle approach from the organizational design of business processes to IT implementation. In addition, the ARIS has an elaborated decomposition of an enterprise in several views: data view, function view, and organization view where all are being realized through the control view.

The data view describes objects, their attributes and inter-object relations. Furthermore, the data view contains events that can initiate and control processes. The function view embodies functions that are part of processes and determined through the creation and change of objects and events. Moreover, relations between enterprise units and their classification into the organizational hierarchy are modelled in the organization view.

The Zachman and ARIS frameworks were both developed independently, but they are highly complementary due to the fundamental idea of their integration. They are implemented to understand a variety of complex issues. Understanding the what, how, where, who, when, and why is a prerequisite for any further investment into IS. The Zachman Framework and ARIS have similar objectives indicated by their comparable design features. Both approaches are highly complementary and are not competitive. The Zachman framework delivers a high level of instruction for designing enterprise architectures. ARIS is capable of depicting all dimensions and levels of the elements in the Zachman framework [Schallert, 2001].

Finally, a clear justification for the need of mastering the complexity of business processes design has been discussed in the literature. The business processes change so fast, accompanied with inconsistency and uncertainty in how precisely they can be modeled. It seems to be impossible to control this fact without succeeding in mastering business processes complexity through modelling and analyzing their contents before they are modified [Biemans, 2001].

Table 2.8: Summaries of The Surveyed Systems Analysis And Design Methodologies

Contents / Framework	Objective	Implementations	Approach
ZACHMAN	Developing &/Or Documenting An Enterprise-wide IS Architecture.	-Practices In Traditional Architecture & Engineering. -Doesn't Support Cost Model -IS Design -Not Implemented On A Tool Set	Resulted In An Approach Which: Vertical Axis Provides Multiple Perspectives Of The Overall Architecture. -Horizontal Axis Provides A Classification Of The Various Artifacts Of The Architecture -Subject Oriented.
CIMOSA	Methodology For Re-engineering Processes To Manage Integrations Difficulties.	Reduced Delivery Time. Improved Quality And Flexibility Of Spare Parts Supply. Usage Of Model To Redesign And Validate The IS.	Object Oriented. It Is Not Currently Possible To Generate Cost Models With Cimosa -IS Design
$IDEF_0$	Useful For Modeling Functional Relationships And Data/Info Flow.	-Represent A Detailed Description For The Inputs, Outputs, Mechanisms, And Controls Of The Business Process Functions And Activities -Support Cost Model -Appear To Be Sequence Process Oriented, Reader Might Be Confused In Case If Modeling Process Is Not - Expert In The Detailed Process Can Follow Up With Its Contents (Technical Oriented)	Object Oriented. Component Choice Depends On: Type Of Business Type Of Task Audience Knowledge Future Implementation Choice Of Language
LOVEM	-Business Innovation -Processes Analyze & Design The Organization -Analyze & Design The Workflows -Analyze & Design Staffing Req.	BPM, and BPM* Support Cost Model	Subject Oriented. Include Customer Line Of Visibility For Monitoring The Enterprise Internal Process.
ARIS	Designing, Implementing And Controlling Business Processes.	BPM, and BPM* Support Cost Model	Subject Oriented Approach Including Four Main Views Of The Enterprise. Function View, Information View, Organization View, And Product View.
UML	-Modelling Language For The Specification, Visualisation, Construction And Documentation Of Software Systems Artifacts.	-Made Up Of A Very Specific Notation And The Related Grammatical Rules For Constructing Software Models. -Doesn't Proscribe Or Advise On How To Use That Notation In A Software Development Process Or As Part Of An Object-oriented Design Methodology -Doesn't Support Cost Model	-Specify, Visualize, And Document Models Of Software Systems, Including Their Structure And Design, In A Way That Meets All Of These Requirements. - Defines Twelve Types Of Diagrams, Divided Into Three Categories: Four Diagram Types Represent Static Application Structure; Five Represent Different Aspects Of Dynamic Behaviour; And Three Represent Ways For Organizing And Managing Enterprise's Application Modules.

Table 2.9: Literature Review Summary

Reference	Objective	Fields of Applications	Design Methodology / Approach	Solution Technique
Bauer, 1992	Improve Communication Of IS Within An Organization.	Effective Communication Of Elements Within The IS.	Map As An Outline Of The Business. IDEF.	Tool Of Communication Between Organizations When Designing An Improvement.
ElMaraghy, 2001	Information Based Design Process Modelling.	Product Development Process.	Modelling And Managing Complexity.	Increase Productivity Of The Engineering Design.
Pearson. 1999	Enterprise Systems Measurement.	IS Development.	Measure, Monitor, Manage And Maximize Elements Of Complex Enterprise.	Integrated Knowledge And Communications In Complex Enterprises.
IBM Global Service, 2000	Major Concepts Of LOVEM.	Business Process And Workflow Design Or Redesign.	Structured Methodology For BPR, BPM.	Analysing And Redesigning Interactions Between Customers And Internal Processes.
Simon, 1994	Theoretical Framework For BPR.	BPR And Rapid Development Of IT.	Framework For BPR.	New Methodologies And Tools For SAD In Dynamic Environments.

Table 2.9: Literature Review Summary (Continue)

Leong, 2000	IDEF Modelling Methodology.	BPM.	$IDEF_X$.	IDEF Technique For Processes Modelling.
KBSI, 2003	Business Evolution Strategies.	System/ Enterprise Analysis.	$IDEF_X$.	Framework For Design, Communicate And Implement Reengineering Solution.
Burlton, 2003	BPM*.	Process Management Theories And Practices.	Process Management Framework To Produce Set Of Guidelines Based On Best Practices.	Improve Business Performance And Implement Continuous Learning.
Bentley et al., 2001.	BPI.	SDD Methods (Part 2 And 3)	Data Modelling And Analysis. Process Modelling.	Determine How People, Data, Process, Communication, And IT Can Accomplish Improvement For The Business.
Doppler, 2003	Managing Corporate Change.	Business Process Change Management.	Tools, Methods And Procedures Incorporate Development.	Strategies For Power Changes With An Organization.
Hammer, 2003	Business Process Change Management.	ARIS.	Work Flow Management.	BPI Change Management.
IDS-Scheer, 2003	ARIS.	Business Process Change Management	Work Flow Management.	Integrated Model Of IS.

Table 2.9: Literature Review Summary (Continue)

Noran, 2004	Business Process Modelling Unified Modelling Language (UML) Vs IDEF.	Business Process Modelling.	IDEF. UML.	Use Software Development Tools/Methods For Business Modelling. Use Business Model As A Template For The Software Development Requirements.
Nye, 1997	Simultaneous Improvement In Manufacturing Systems And Effect On Investment Decisions.	Manufacturing Improvements Practices.	Economic Systems Model.	Determining Optimal Investment Strategies When Working On BPI.
Saven, 2003	Process Modelling: Review and Framework.	Business Process Modelling/ Reengineering.	Flow Chart Technique. Data Flow Diagram – Interaction. OOM.	Process Modelling Methodologies that Provide a Comprehensive Understanding of a Process.
Schallert, 2001	How ARIS facilitates the Zachman Framework.	Successfully Building Enterprise Architectures.	ISA.	Zachman and ARIS can be employed to Understand the what, how, where, who, when and why is a prerequisite for any further investment into IS.

Table 2.9: Literature Review Summary (Continue)

Sparks, 2000	UML/ Processes Modelling.	BPM.	UML	OOM for system design where it provides a set of concepts and language elements that can be used to model different aspects of the business processes.
Sue, N., 1999	A Theory of Complexity, Periodicity and the Design Axioms.	Complexity in Systems Design.	Design Axioms.	Stable and reliable system needs to be periodic. Mr. Sue realized how a coupled system was decoupled through design changes and how a combinatorial complexity problem could be changed into a periodic complexity design problem.
Trautmann, 2000	Executive Summary Of A LOVEM.	BPM*	LOVEM.	BPM* By Using (LOVEM)

2.5 Literature Review Conclusions

From the literature conducted within the BPM domain, it is very crucial to mention that enterprises have to be organized in a business process oriented way. This is in order to be successful in a changing and challenging business environment including uncertainty and complexity in managing business and manufacturing processes.

Structured frameworks known as enterprise architectures can capture and manage the complexity of today's organizations. Organizations can be defined as systems consisting of elements such as objectives, data, people, processes, and technology. Complex systems require coordination and integration in order to manage the existing interdependencies between all these components.

Organizational complexity derives from the number and variety of elements and relationships that have to be managed. Complexity management can be very time and cost consuming. Typically, it is approached in two phases. First, complexity is reduced. Typical approaches include the reduction of variants or the selection of preferred vendors. Second, the remaining complexity has to be managed by the organization. Both phases of complexity management require a precise understanding of the entire structure of an organization in all its facets. Furthermore, interfaces between components need to be identified and analyzed within the enterprise architecture.

Business environment is constantly changing as a result of new customer requirements or products, market competition, and new IT solutions. The complexities in managing new business designs have led to such change. In addition, the lack of powerful tools as well as methodological deficiencies particularly with regard to capturing complex process logics and dynamics are considered to be major obstacles for a successful re-engineering of business processes.

Organizations interested in designing enterprise architectures should not only consider the appropriateness of enterprise architecture frameworks, but also the availability of corresponding tools, the easiness of handling the approach, and the integration of all components. The SAD with optimal processes modelling methodologies is the key issue for companies to regain competitiveness and profitability in increasingly unstable markets. Also, it will lead in managing operational complexities, conflicts in priorities, contention for resources, and also the business communication problems.

CHAPTER 3

BUSINESS PROCESSESS MODELLING CASE STUDY

3.1 Background

In Canada, professional engineers are licensed, and are accountable for their work. Their duty is to serve and protect the public welfare where engineering is concerned. Professional engineers subscribe to a strict code of ethics and practice standards. Professional Engineers Ontario (PEO) council regulates the practice of the profession in the province of Ontario.

The PEO council is the organization that is mandated, under the Professional Engineers Act in Ontario. It regulates the practice of professional engineering and governs those individuals and organizations that PEO licenses to serve and protect public interest [PEO Council, URL: http://www.peo.on.ca/].

The PEO council is committed with setting standards for admission and with regulating the practice of professional engineering in Ontario. It also protects the public by ensuring all professional engineers are qualified for licensing. The PEO council is also mandated to carry out the following additional objects under the act:

1. Establish, maintain and develop standards of knowledge and skill;
2. Establish, maintain and develop standards of qualification and standards of practice for the practice of professional engineering;
3. Establish, maintain and develop standards of professional ethics; and
4. Promote public awareness of the role of PEO.

Currently, there are 64,000 licensed professional engineers in Ontario, organized in thirty eights regional chapters across the province. Companies and individuals may not offer or provide engineering services to the public unless they obtain a PEO certificate of Authorization. There are approximately 3800 certificates of authorization holders in Ontario.

The act gives the PEO council the power to make regulations for its administration. For instance, fixing the number of professional engineers elected to council and standards of professional engineering practice such as setting a code of ethics. In addition, it permits PEO to make by-laws relating to its administrative and domestic affairs.

As illustrated in Figure 3.1, applicants must meet certain criteria to be licensed and recognized as professional engineers. They must be at least 18 years of age and are determined to be Canadian citizen or permanent resident of Canada. In addition, applicants must be graduates with at least a bachelor's degree from an accredited Canadian engineering program. Such program needs to be accredited by the Canadian Engineering Accreditation Board (CEAB), or meet PEO's education standards [PEO Council, URL: http://www.peo.on.ca/; R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)].

There is a minimum educational level required by the Professional Engineers Act. The council policy has established a three-year diploma in technology from a College of Applied Arts and Technology. Also, a bachelor's degree in a relevant science area or academic qualifications determined by the Council to be equivalent to a diploma or degree mentioned above as the minimum academic qualifications.

If bachelor's degree in engineering was obtained from a non-CEAB accredited program, applicants' qualifications will be assessed against the Canadian Engineering Qualification Board (CEQB) criteria in the specified engineering discipline. That requires further steps the PEO council needs to follow if "determined to be a non-CEAB accredited program" is concluded from the PEO's Academic Requirement Committee (ARC). Final decision of the academic credential in this case is dependent on the experience credentials to be evaluated by the PEO's Experience Requirements Committee (ERC). This is occurred if requested by the ARC. The PEO council gives its perspective applicants an opportunity to demonstrate that their academic preparation is equivalent or to remedy any identified deficiencies. This is through enrolling applicants in the Confirmatory Examination Program (CEP) by the ARC. However, applicants of engineering background obtained from a non-CEAB accredited program who have more than five years of engineering experience may have their CEP waived if their experience provides any basis to warrant exam relief. It is important to mention in this part that in this application's evaluation stage, an applicant can be refused when the ARC finds that the applicant doesn't have sufficient academic credential to satisfy the PEO's licensing regulations set by the Government of Ontario.

As demonstrated in Figure 3.1, applicants need also to successfully complete the PEO's Professional Practice Examination (PPE) on ethics, practice, engineering law, and professional liability. All applicants for licensing must pass the PPE, a three-hour examination. It requires essay type responses to questions that cover ethics, professional practice, engineering law and professional liability. It is held three times a year in the spring, the summer, and the fall. The PPE must be written within two years of the date on which applicants become eligible to do so. Applicants are informed by PEO of these dates during the licensing process. According to the PEO Council [URL: http://www.peo.on.ca/], applicants who do not hold an undergraduate degree from a CEAB-accredited program must have their academic qualifications reviewed. Applicants are required to meet the PEO's council academic qualifications before they are eligible to write the PPE. Also, four years of verifiable, acceptable work experience, with at least one year in a Canadian jurisdiction under a licensed professional engineer is mandatory. PEO evaluates each applicant's engineering experience against five, quality-based criteria:

- Application of theory;
- Practical experience;
- Management of engineering;
- Communication skills; and
- Awareness of the social implications of engineering.

Applicants are required to demonstrate a minimum of 48 months of verifiable, acceptable engineering experience, gained following the completion of their undergraduate engineering degree, unless they were assigned a "failed-to-confirm". In such cases, the engineering experience starts when the PEO examination program is completed. Applicants may be eligible to receive credit for up to 12 months of pre-graduation experience toward the 48 months of required experience. This experience must be relevant to the overall practice after graduation. Also, it must be obtained after the midpoint of the undergraduate engineering program [PEO Council, URL: http://www.peo.on.ca/; R.R.O; R.S.O].

The PEO Council [URL: http://www.peo.on.ca/] has stated that applicants can receive credit for the equivalent of 12 months of experience toward the 48 months of required experience for successfully receiving a postgraduate engineering degree(s). Eligibility to receive the credit is limited for associated applied industry-research thesis work. Such work needs to be conducted within the framework of postgraduate degree requirements.

The 12 months' credit related to the award of the postgraduate degree cannot exceed the time dedicated to complete the postgraduate degree requirements. It must acquire at least 12 months of acceptable engineering experience in a Canadian jurisdiction, under a licensed professional engineer. In addition, the experience must also be gained at the prior to graduation stage and/ or the 12 months credit, for successfully receiving a postgraduate degree(s). A credit related to the applied research of the postgraduate degree can assist to meet the requirement for engineering work experience in a Canadian jurisdiction.

Practice of professional engineering by the holder of a limited licence (individuals who, as a result of ten or more years of specialized experience, has developed competence in a certain area of professional engineering) must be limited to the services specified in the limited licence. The practice of professional engineering by the holder of a limited licence must be limited to work in the employer named in the limited licence. The minimum requirements and qualifications include having a three-year diploma in engineering technology or a bachelor of technology degree in engineering technology from an institution approved by the Council. Also, a four-year honours science degree in a discipline and from a university approved by the council. In addition, the academic qualifications must be accepted by the council as equivalent to a diploma or degree mentioned in the previous two requirements and qualifications.

Applicants who hold an undergraduate degree from a CEAB accredited program are eligible to register in the PEO's Engineering Intern Training (EIT) program. Similarly, applicants who have been assigned the CEP or have completed their SEP are also eligible to be recorded in PEO's EIT Program. The annual fee for the EIT program is CD$50 +applicable taxes and is in addition to the application fee of $175 +applicable taxes. The fee of the PPE fee is $100 submitted with the application to write the PPE that PEO sends to applicants.

Finally, candidates of the CEP are required to pay a one-time administration fee of CD$285 and CD$115 +applicable taxes for each examination. Instead for professional engineers to remain licensed, they are required to pay annual dues, which are $200 + applicable taxes.

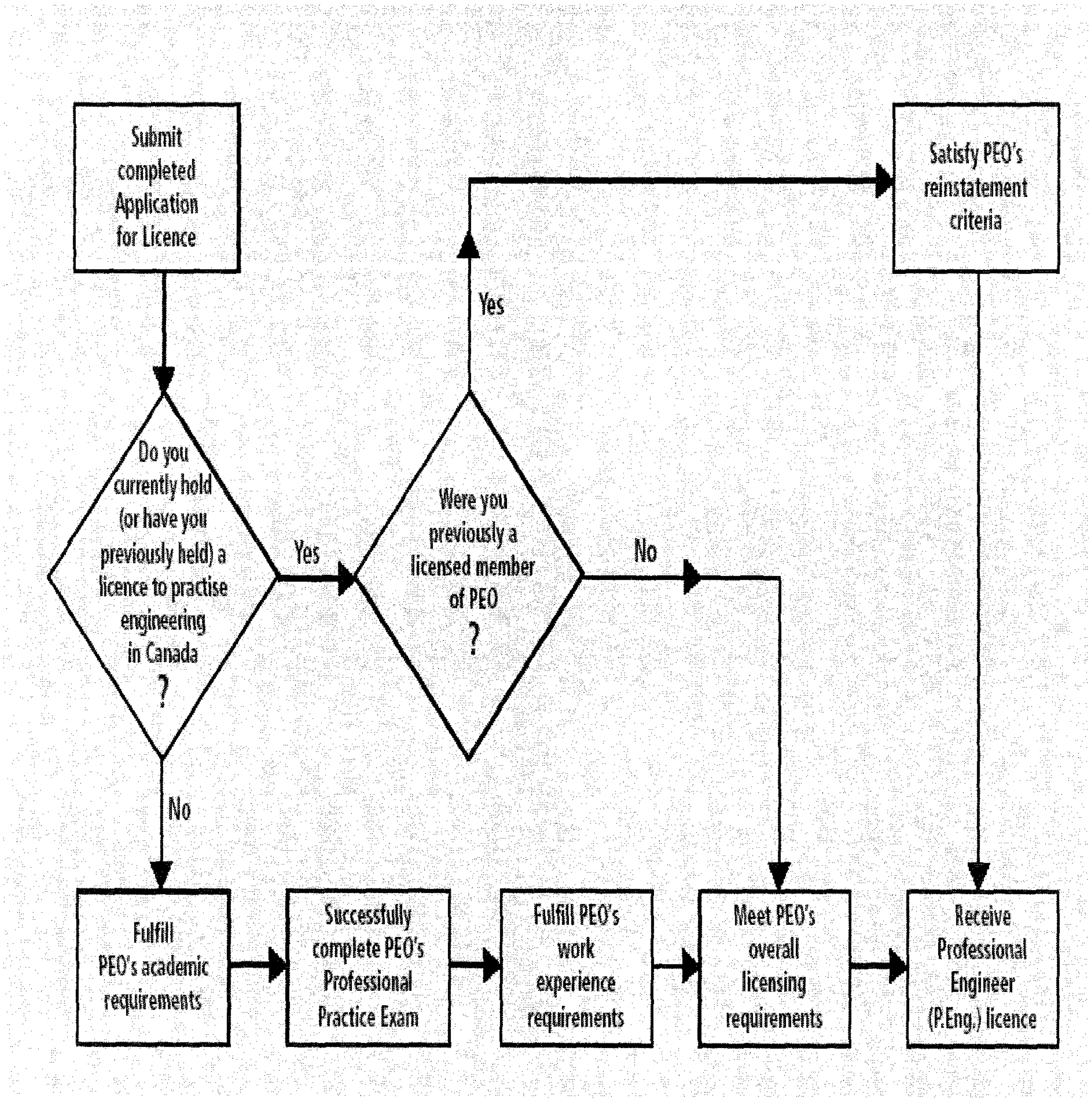


Figure 3.1: PEO's Licensing/Admission Process
[PEO Council, URL: http://www.peo.on.ca/]

In this case study, complexity concerns the structure of the PEO's legislated licensing processes. Variety of their elements and relationships between them make these regulated processes complex. If they are changed in an ad hoc manner because of future government regulations, a successful trial to master only the business processes regardless of their complexity by modelling them will be achieved.

With regard to complexity in business processes activities, Biemans [2001] mentioned that a "major reason that business processes appear complex is the fact that the human mind cannot easily deal with them. This is because the human mind are used to reason about a three-dimensional world whereas business processes like software do not fit in a simple geometric representation. Most people need years of training before they understand business processes and can reason about them".

According to Schallert [2001], organizational complexity derives from the number and variety of elements and relationships that have to be managed. Complexity management can be approached. This includes reducing the complexity first, and second is managing its remaining by the organization.

This brief description of the complexity that accompanies the legislated business processes associated with the PEO licensing processes has triggered the need for modelling them correctly. The processes modelling work will be achieved by including all their elements' variety and their relationships between them, before they are modified. This will be demonstrated next.

3.2 Process Flow Charting

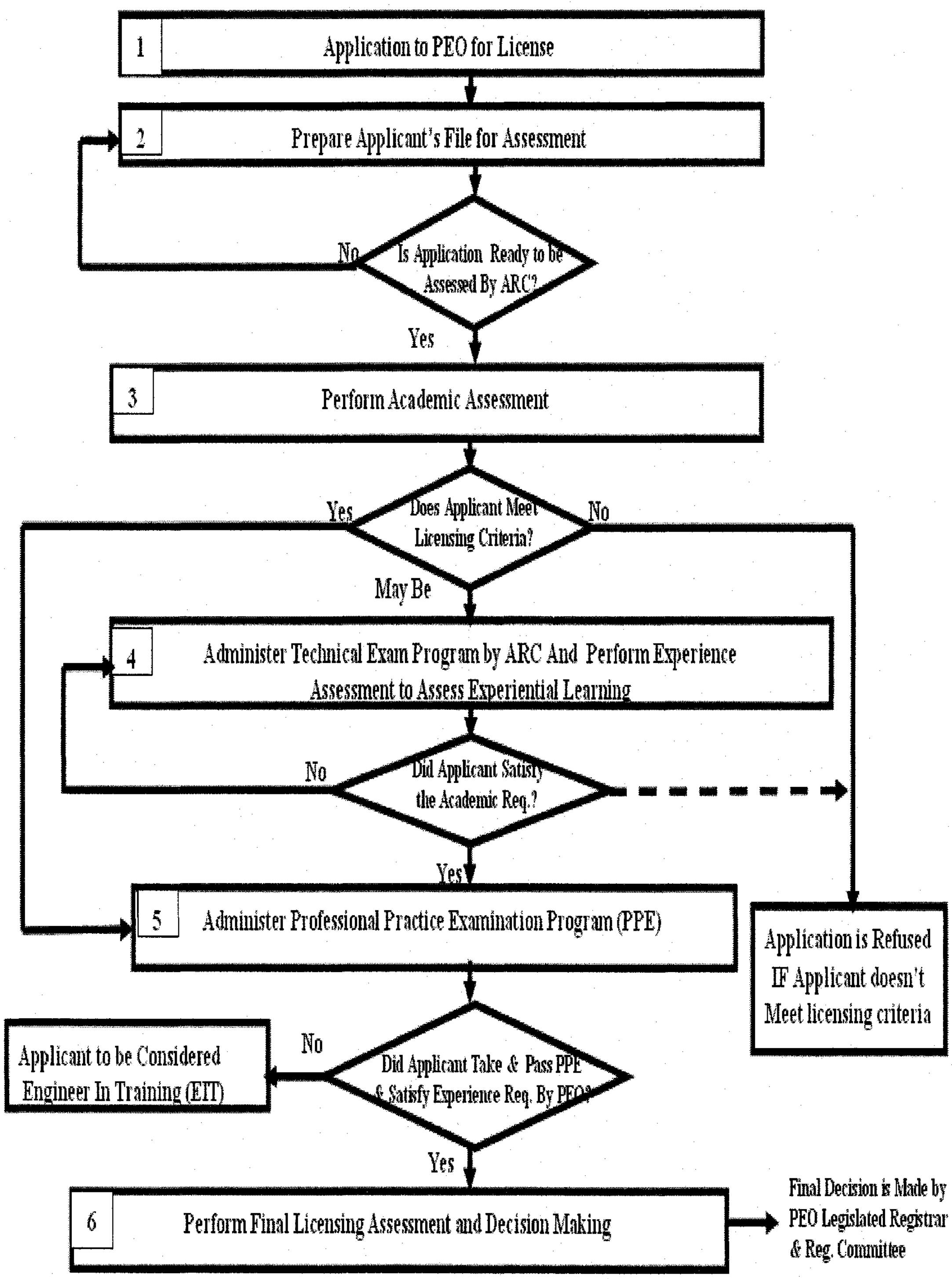


Figure 3.2: Flow Chart Of The PEO's Licensing Process

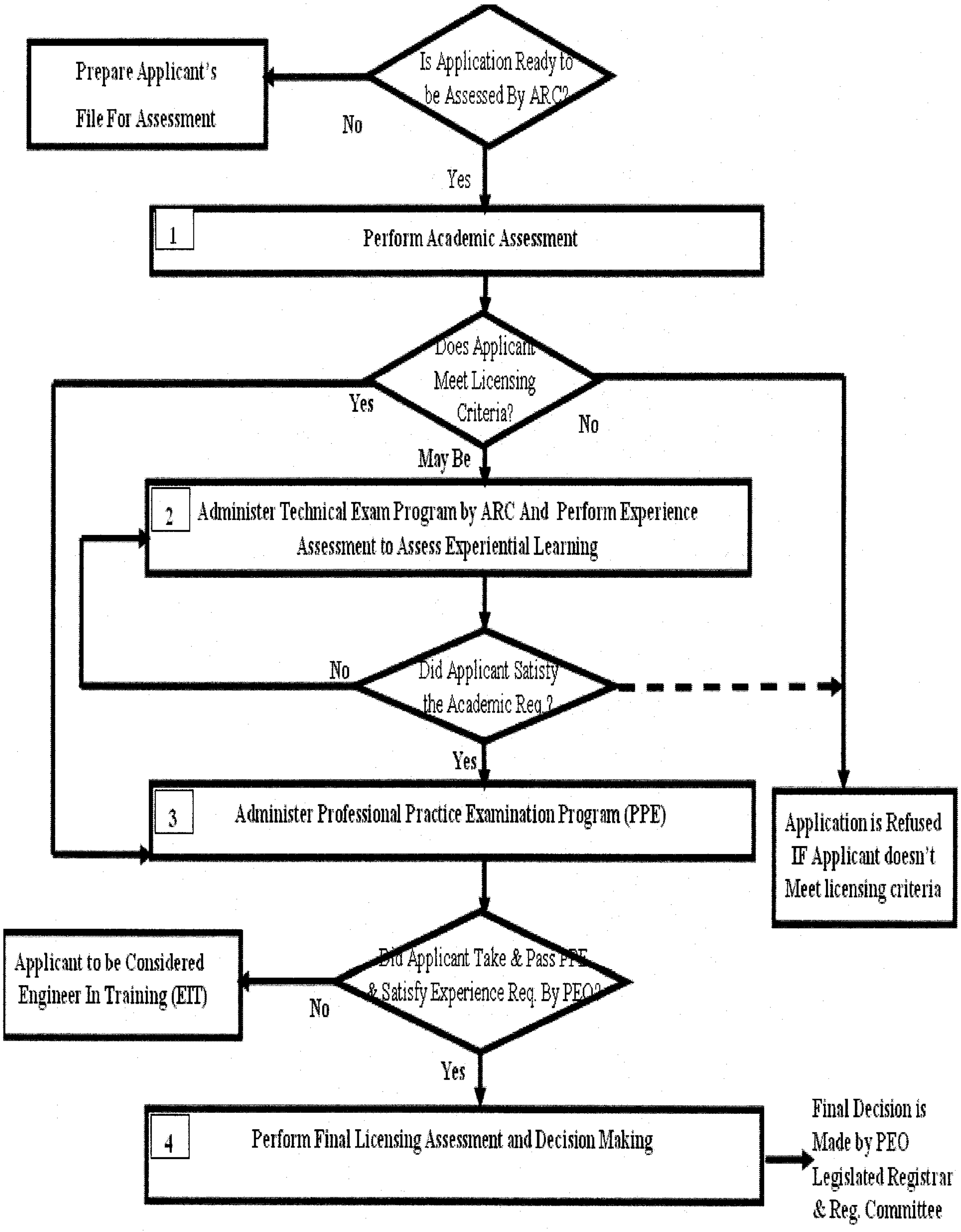


Figure 3.3: Flow Chart Of The PEO's Academic Requirement Committee Licensing Assessment Process

3.3 IDEF$_0$ Representation

3.3.1 Power Point Representation

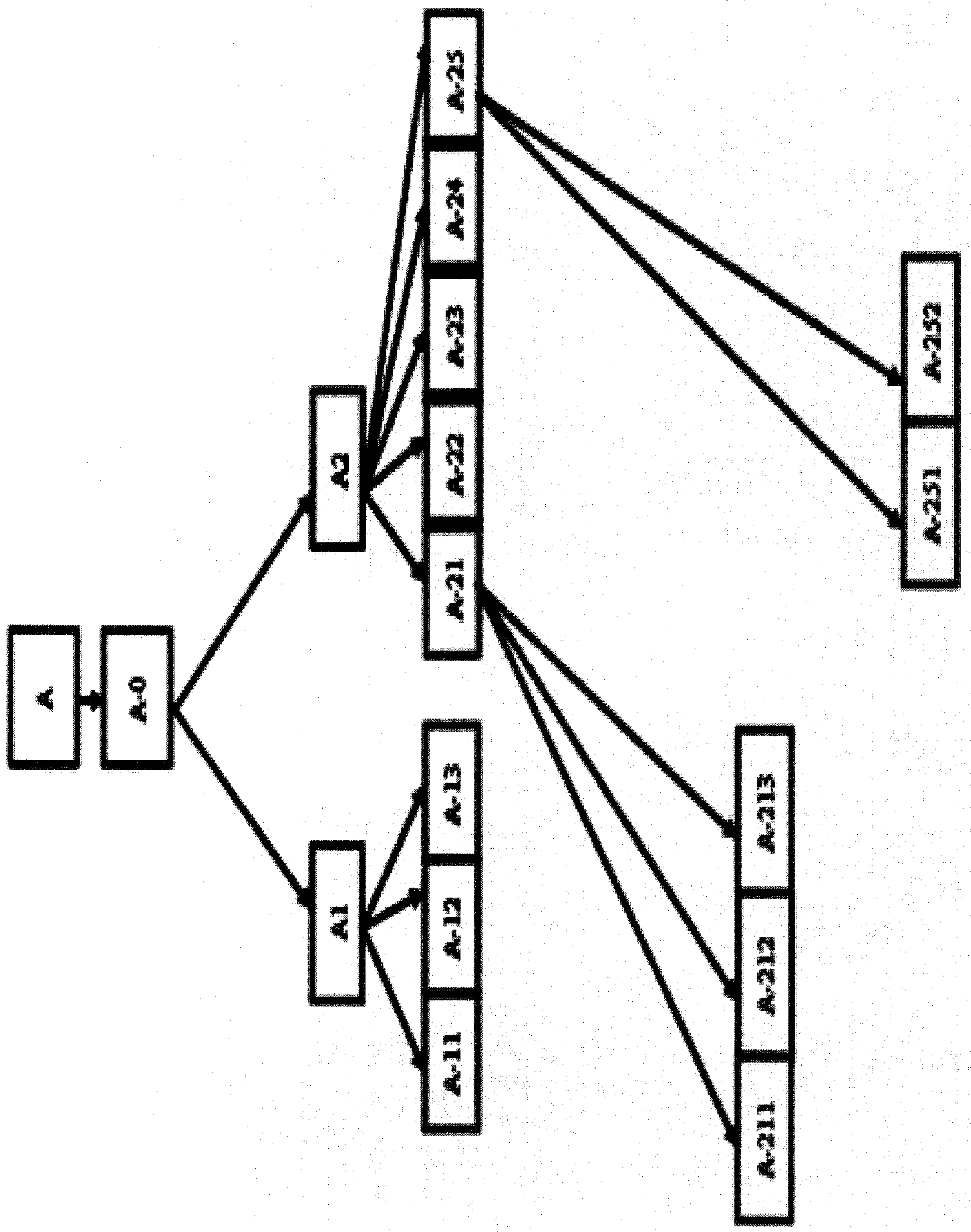


Figure 3.4: IDEF$_0$ Power Point Representation Of The Expanded Tree Diagram Of The PEO's Licensing Processes Procedure

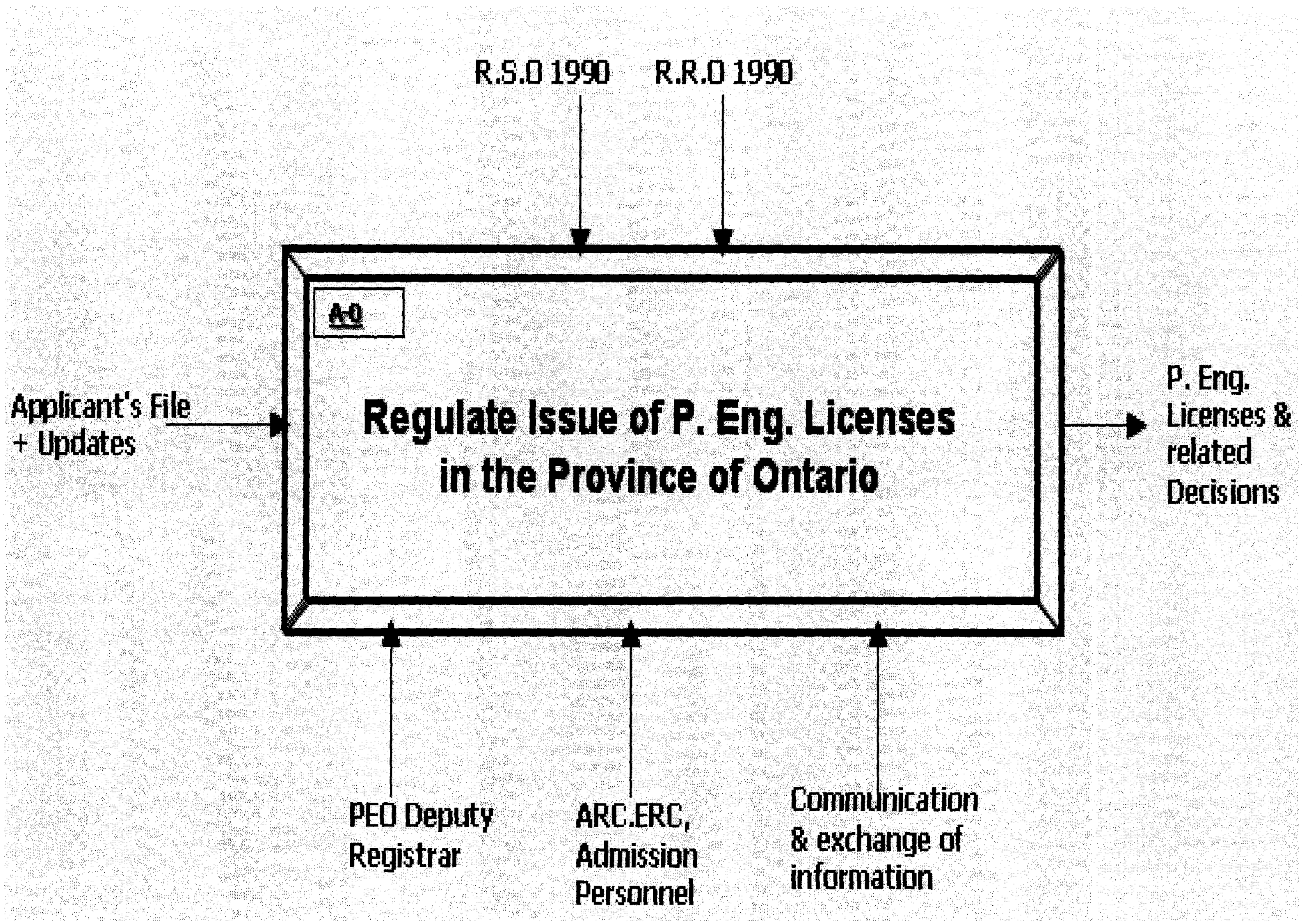


Figure 3.5: IDEF$_0$ Power Point Representation Of The PEO's Licensing Process Procedure (A0)

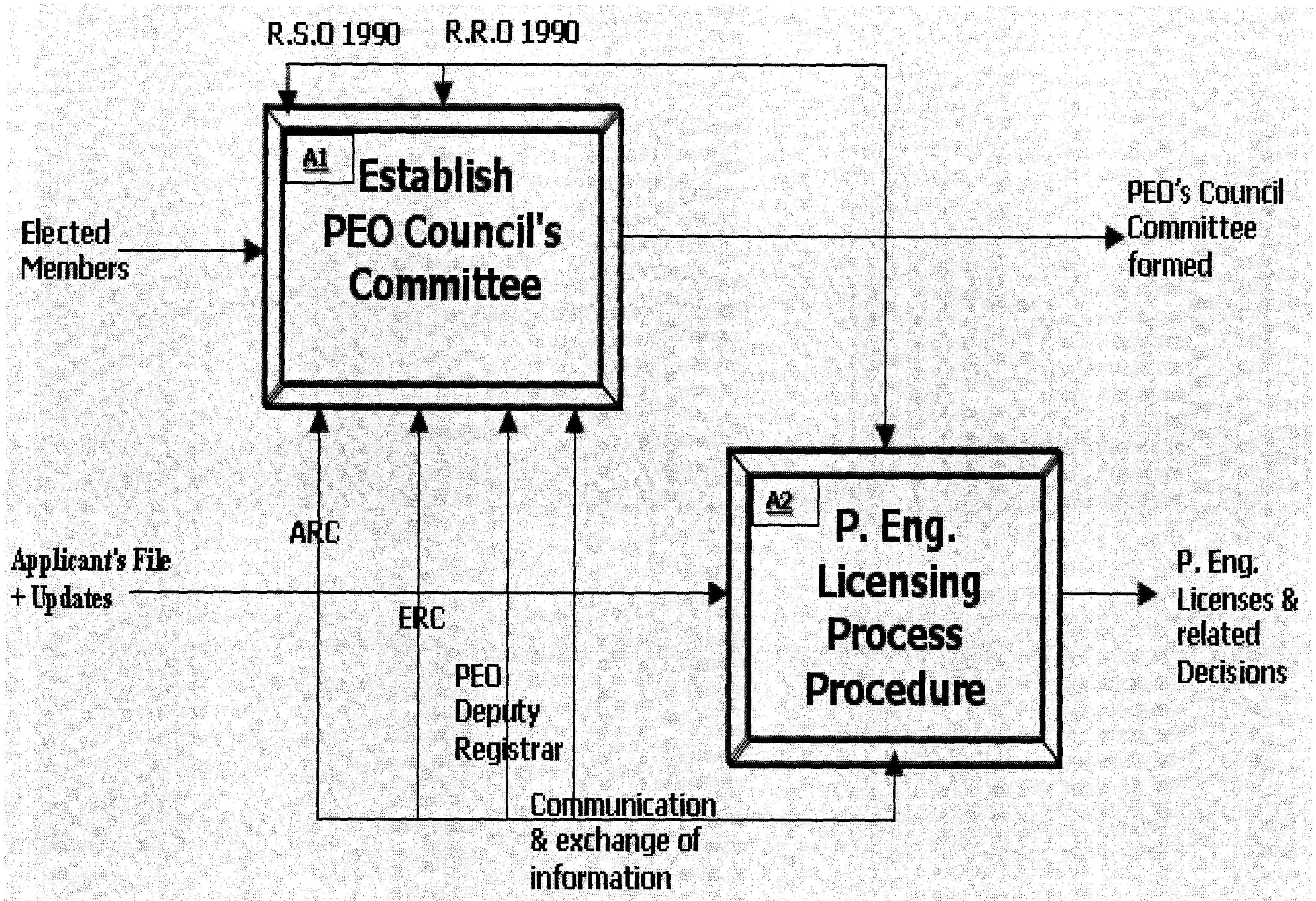


Figure 3.6: IDEF$_0$ Power Point Representation Of The PEO's Licensing Process Procedure (A0 Decomposition)

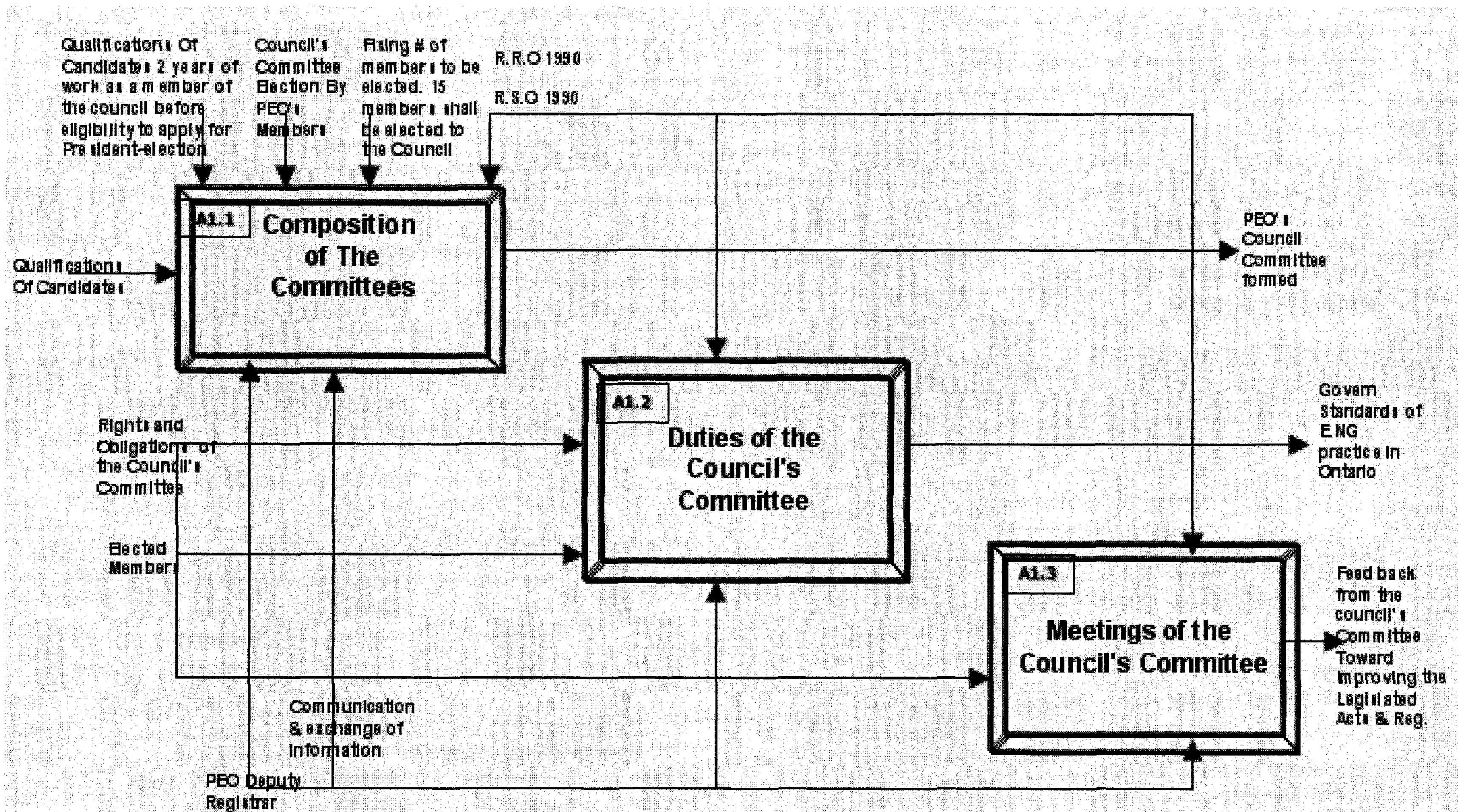


Figure 3.7: IDEF$_0$ Power Point Representation Of The Decomposition Of A1: Establish PEO Council's Committee

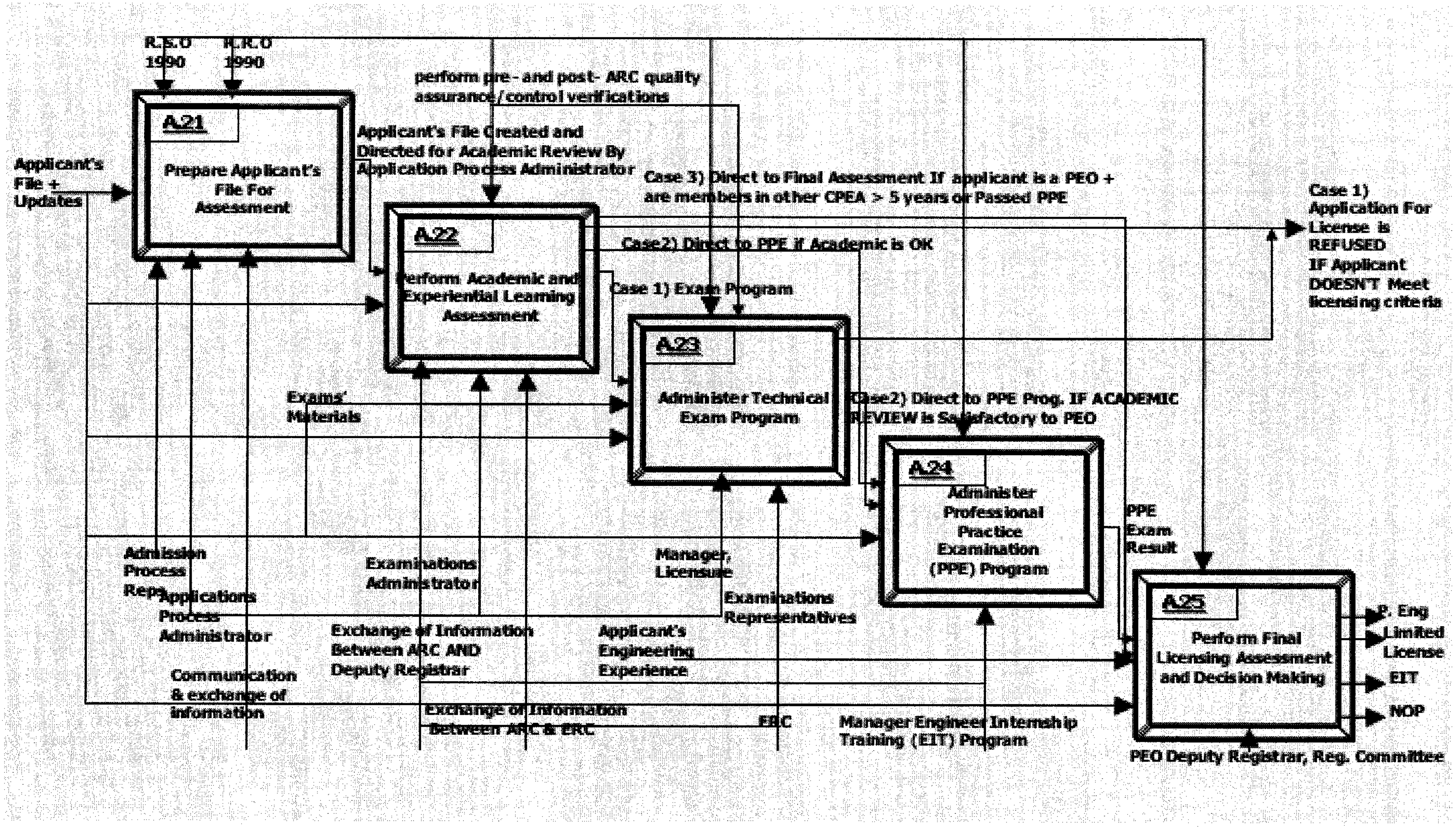


Figure 3.8: IDEF$_0$ Power Point Representation Of The Decomposition Of A2: P. Eng. Licensing Process

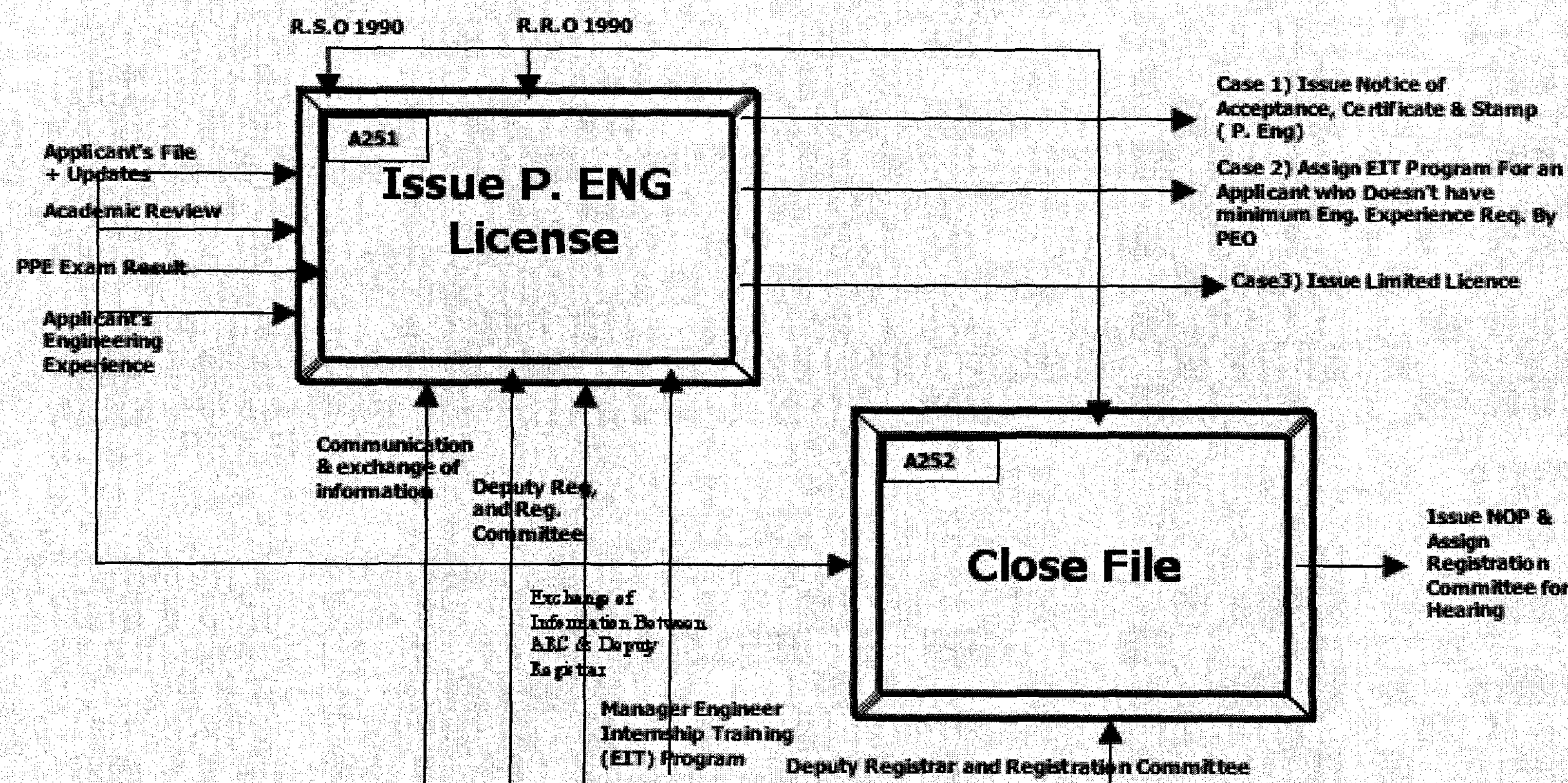


Figure 3.9: IDEF$_0$ Power Point Representation Of The Decomposition Of A25: Perform Final Licensing Procedure

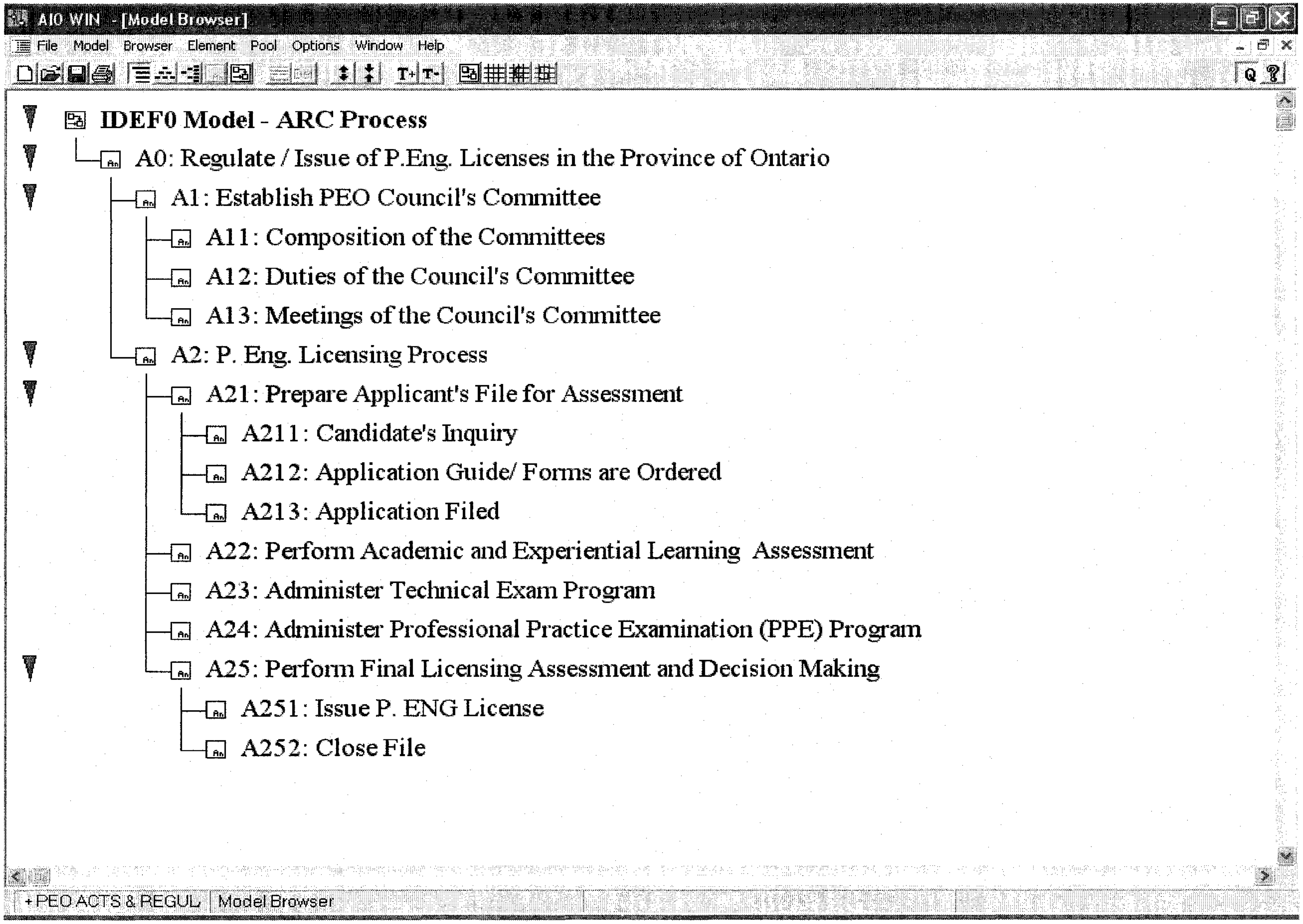


Figure 3.10: IDEF$_0$ – AI0WIN7 Representation Of The Expanded Modeled PEO's Licensing Process

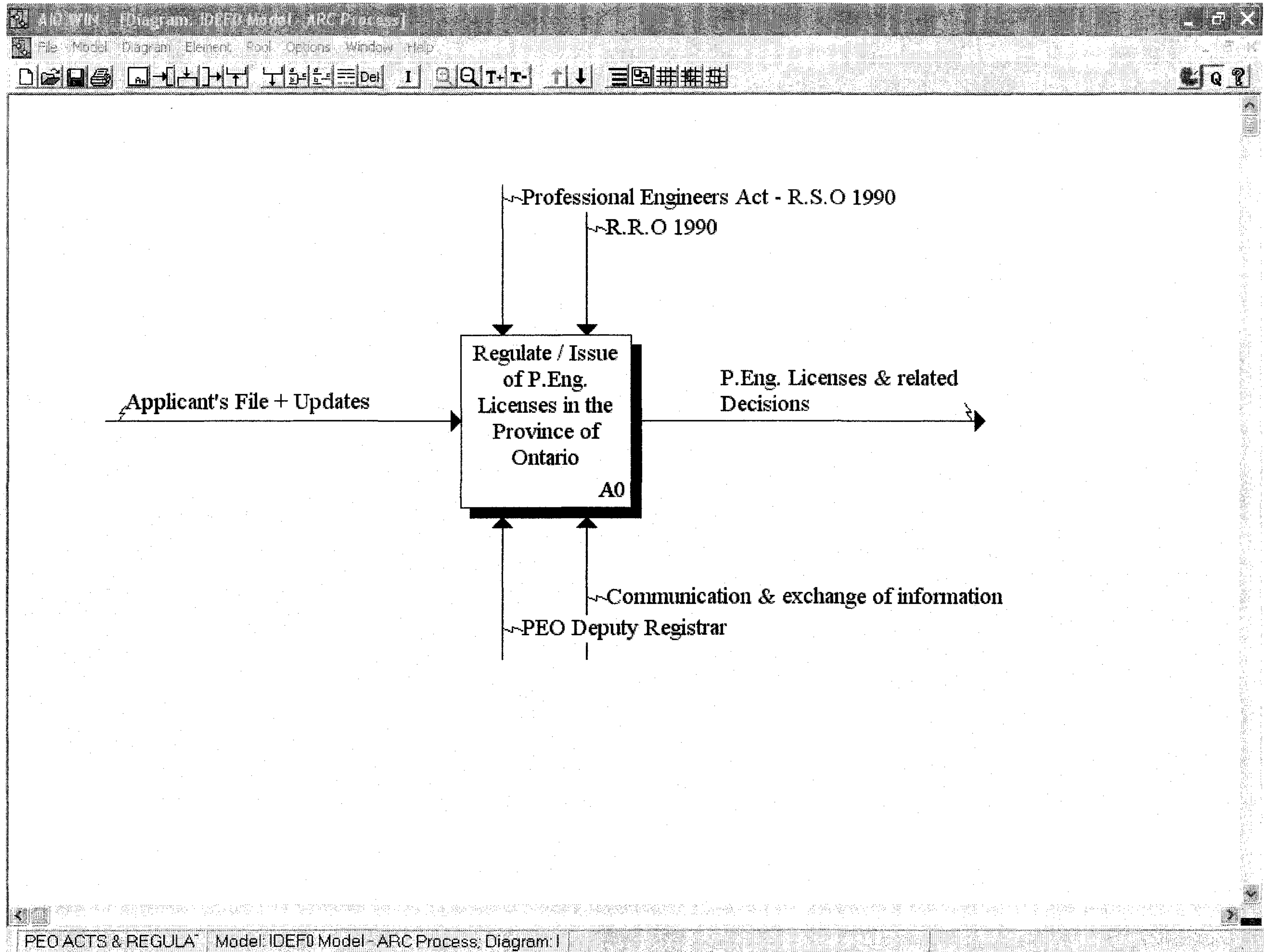


Figure 3.11: $IDEF_0$ – AI0WIN7 Representation Of PEO's Licensing Process Model (A0)

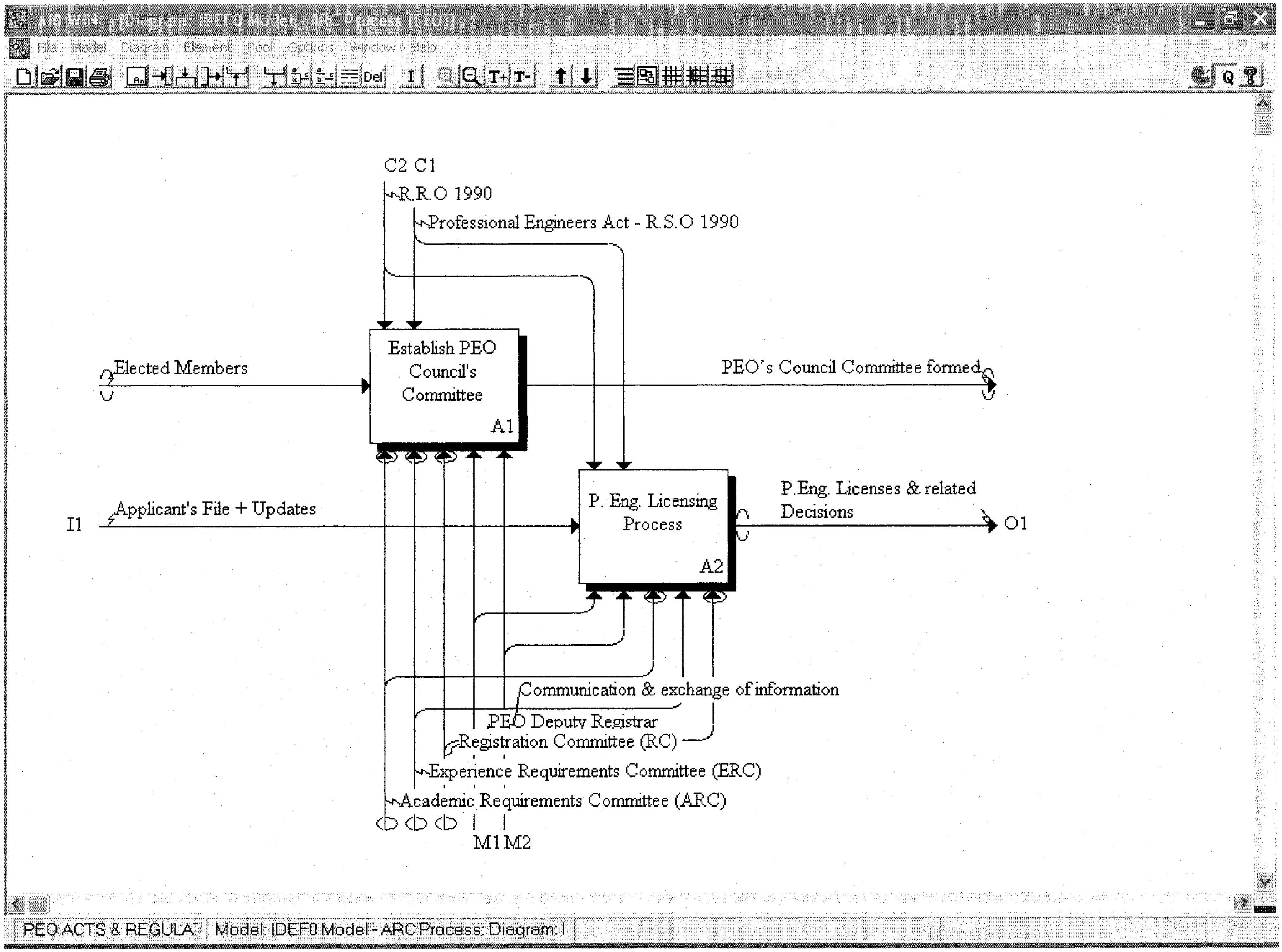


Figure 3.12: IDEF$_0$ – AI0WIN7 Representation Of PEO's Licensing Process Model (A0 Decomposition)

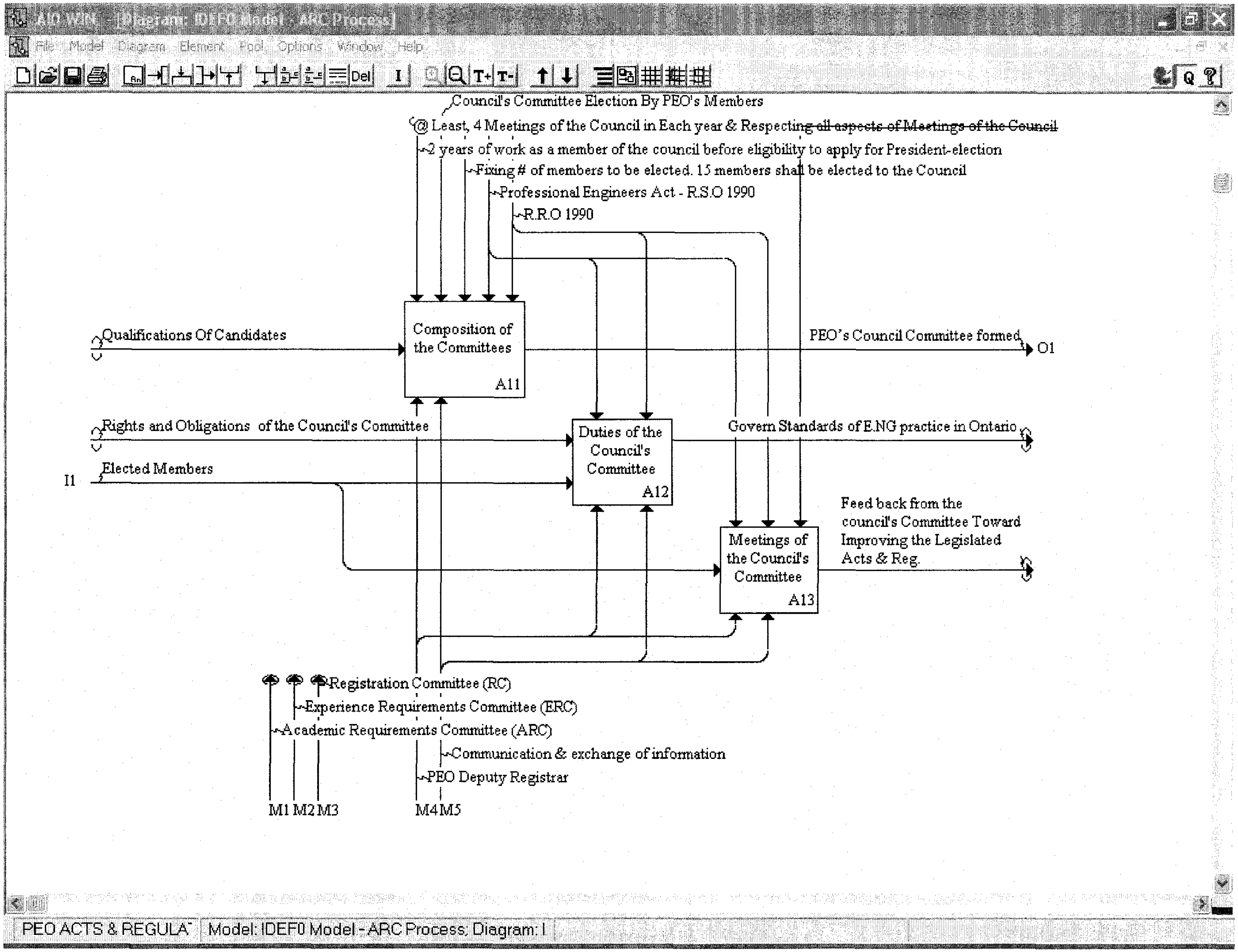


Figure 3.13: IDEF$_0$ – AI0WIN7 Representation Of The Decomposition Of A1: Establish PEO Council's Committee

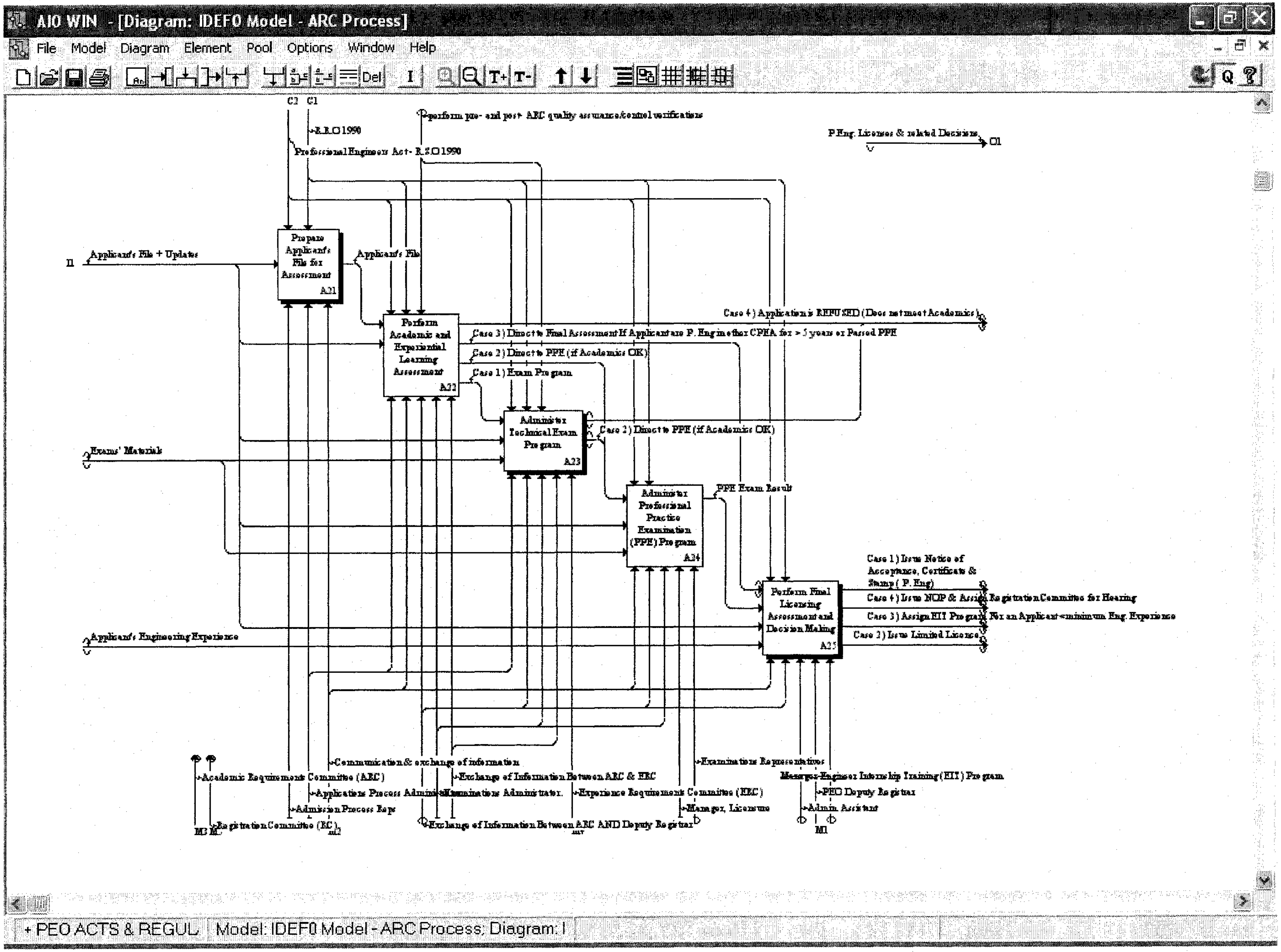


Figure 3.14: IDEF$_0$ – AI0WIN7 Representation Of The Decomposition Of A2: P. Eng Licensing Process

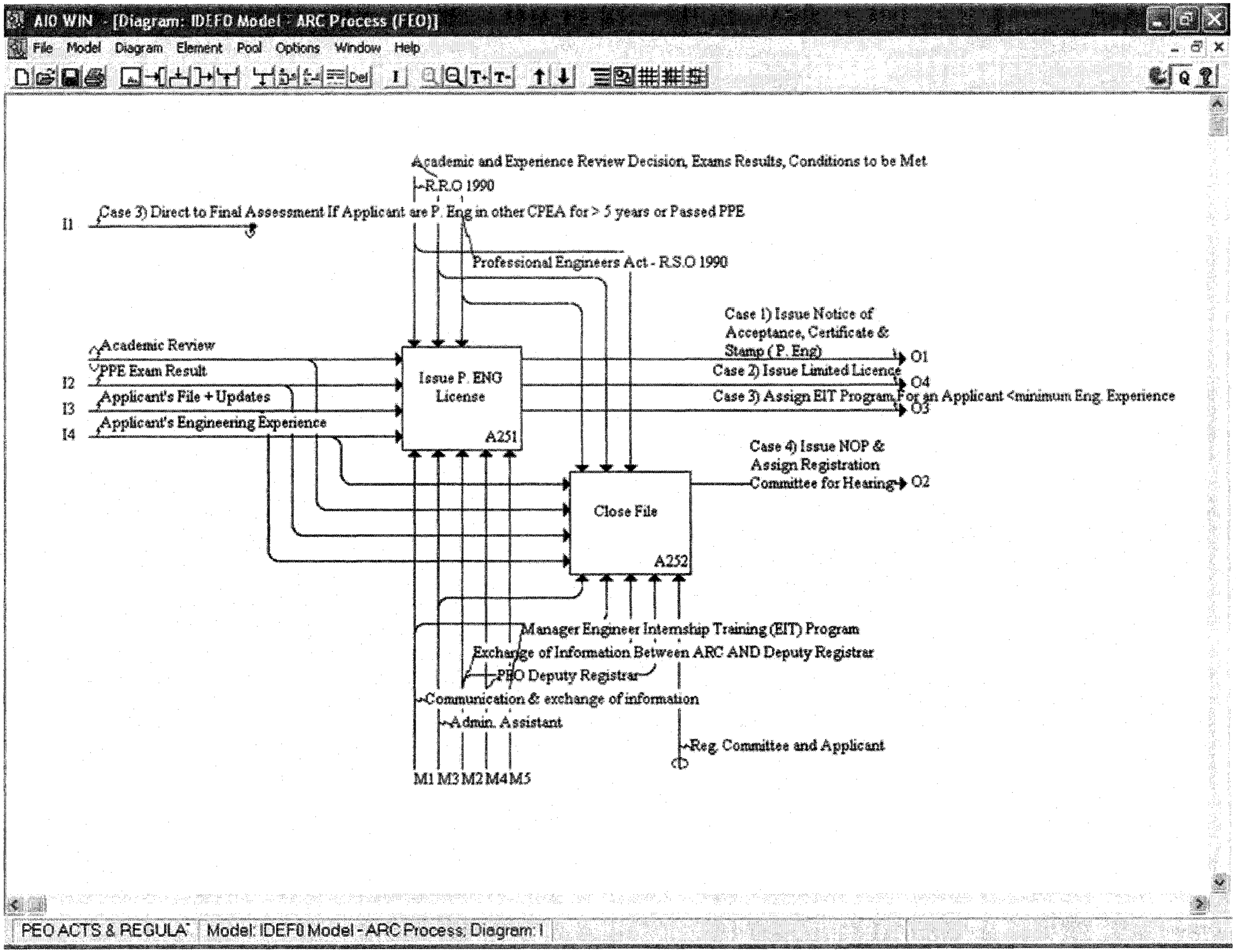


Figure 3.15: IDEF$_0$ – AI0WIN7 Representation Of The Decomposition Of A25: Perform Final Licensing Assessment

3.4 Line Of Visibility Enterprise Modelling Representation

3.4.1 Power Point Representation

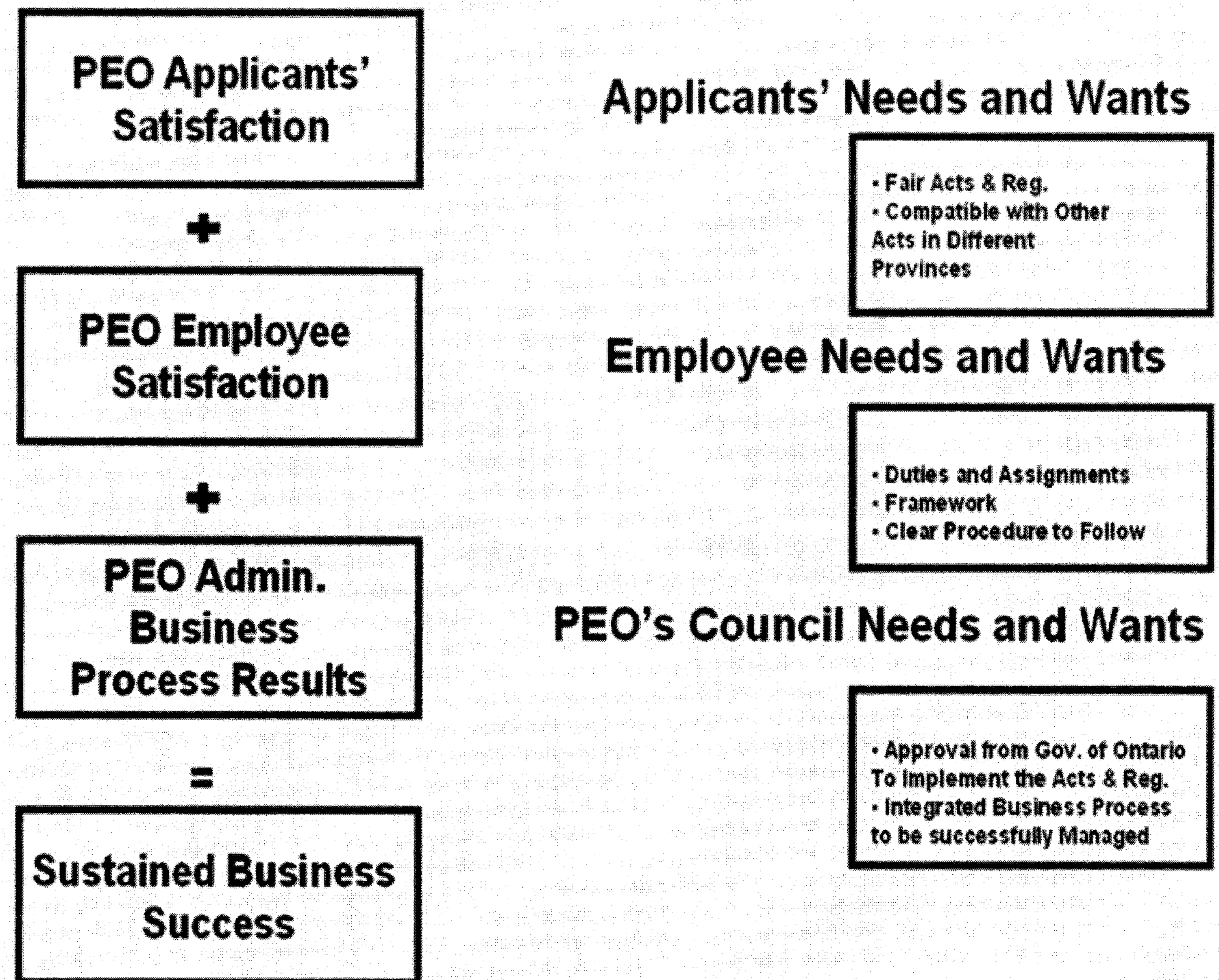


Figure 3.16: Line Of Visibility Of The PEO's Needs And Wants

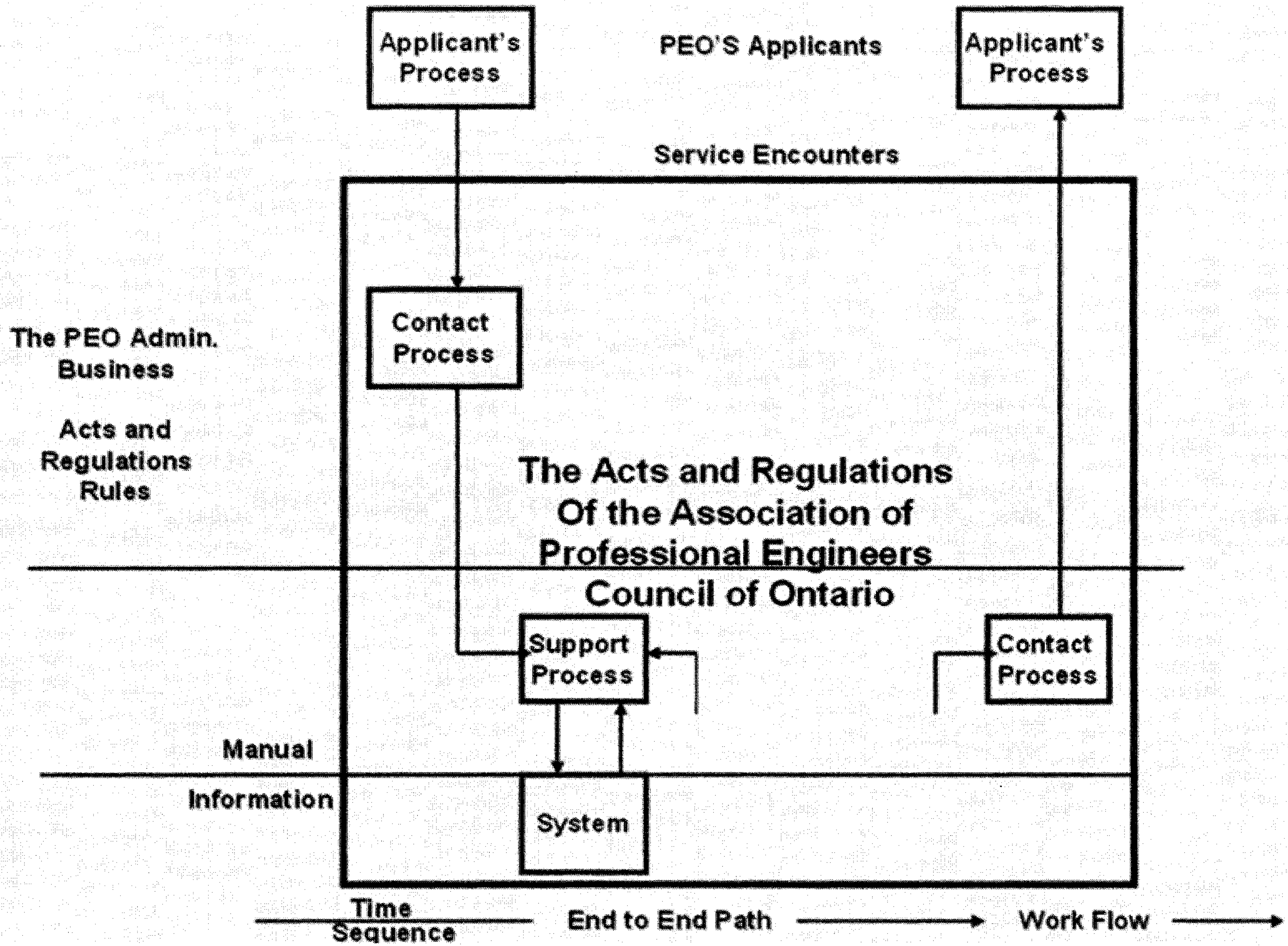


Figure 3.17: Line Of Visibility Chart Of The PEO's Licensing Procedure

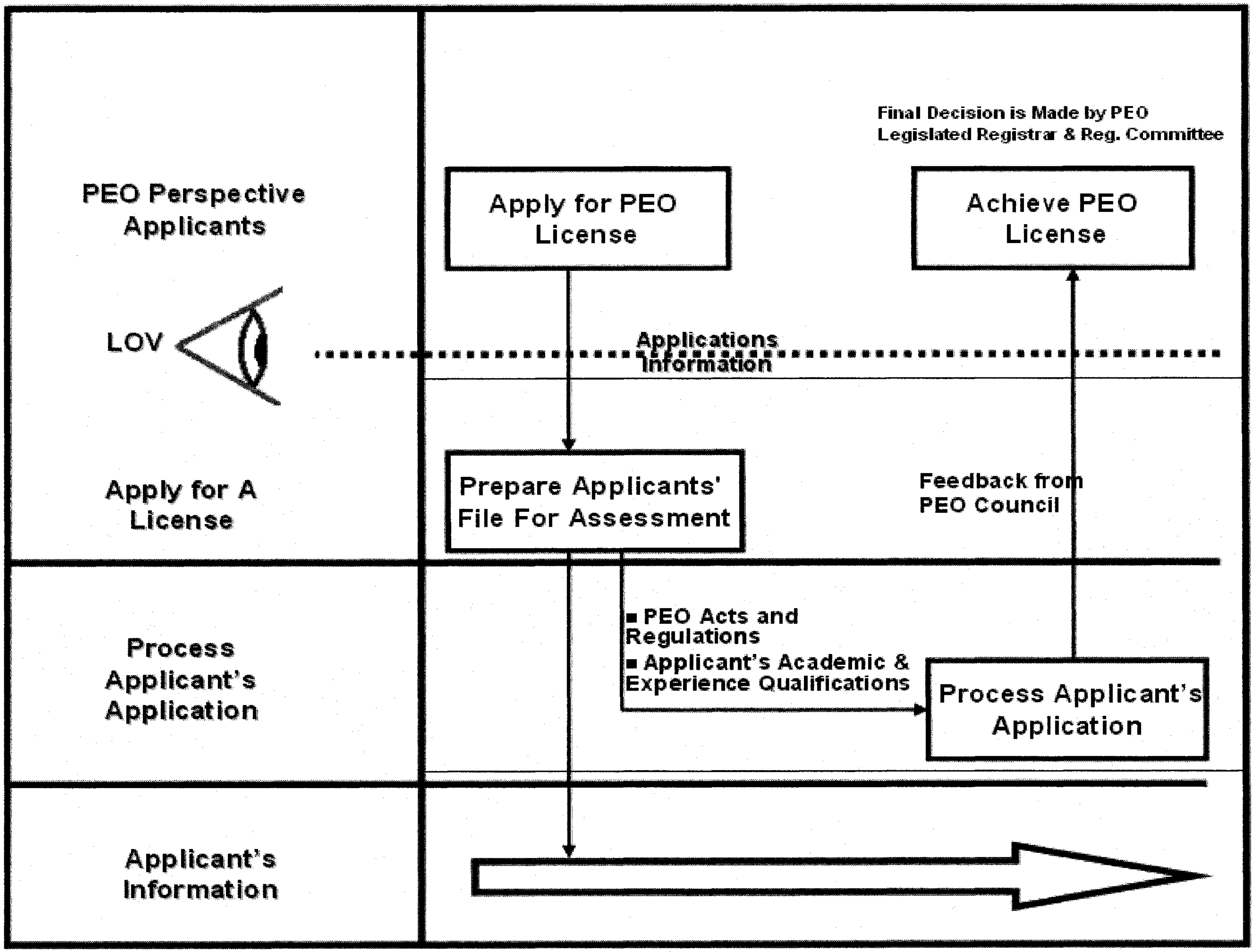


Figure 3.18: Selected LLOV Chart For Modeling the PEO Licensing Processes Procedure

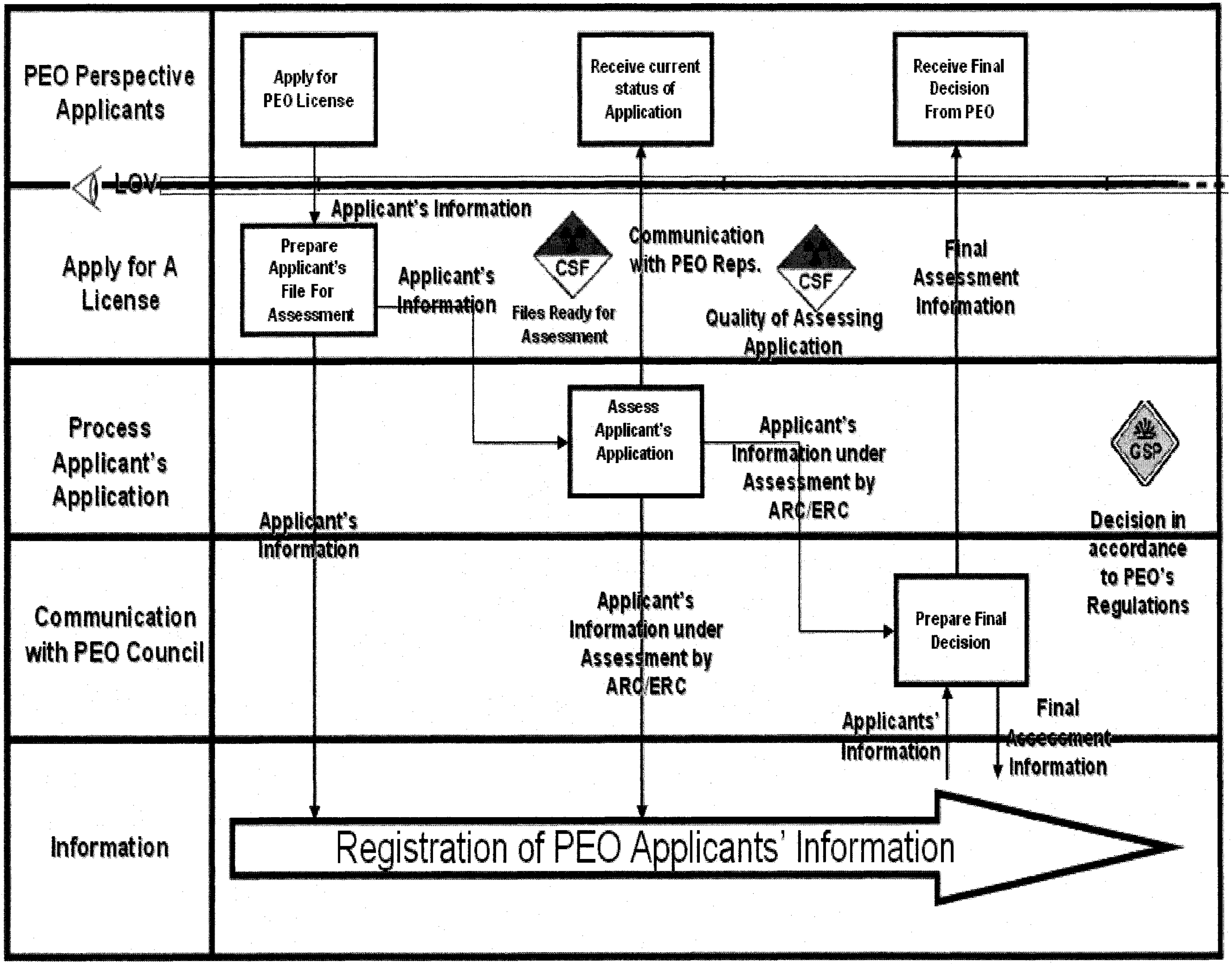


Figure 3.19: Selected LLOV Chart For PEO's General Licensing Procedure

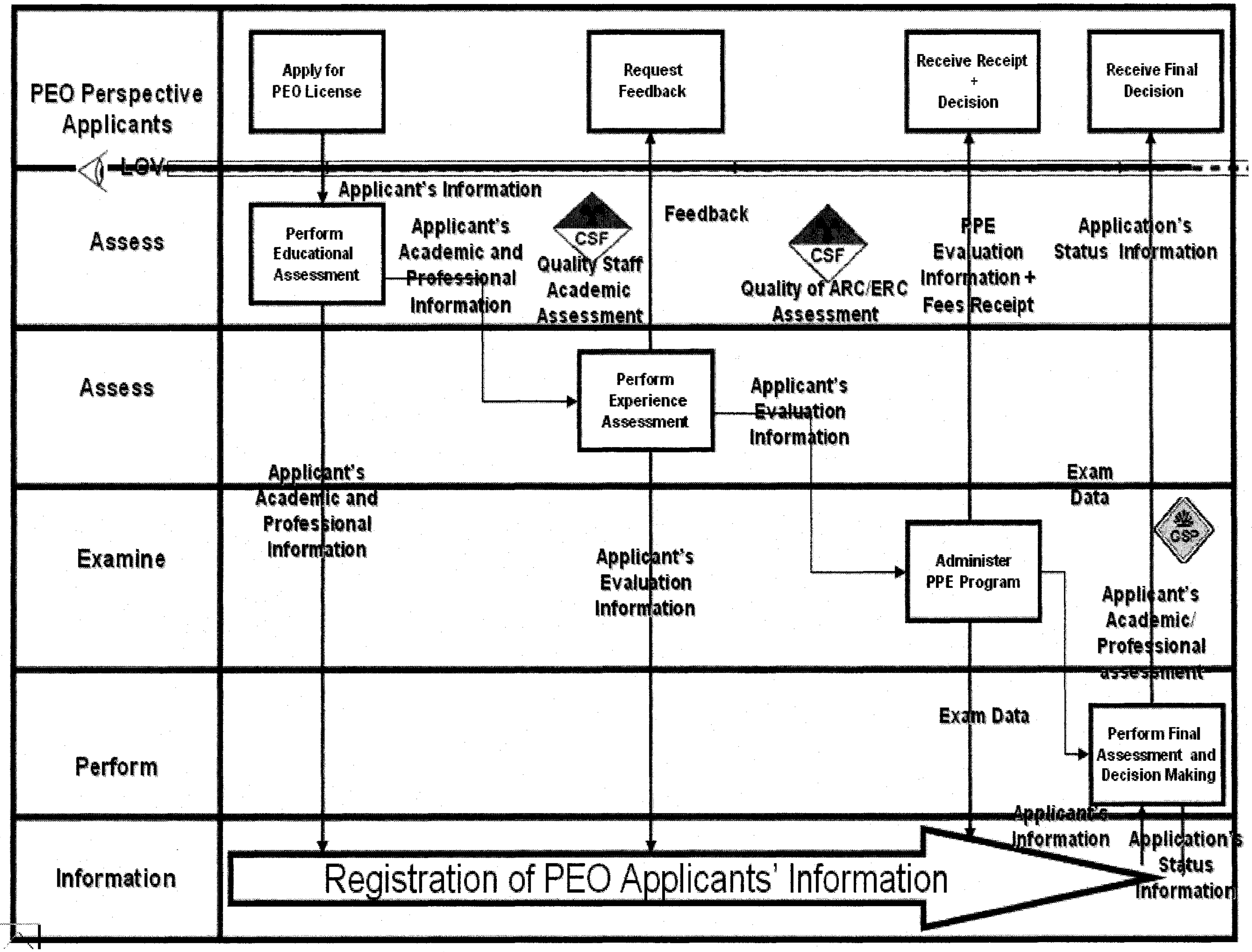


Figure 3.20: Selected LLOV Chart For Modeling the Legislated PEO's Licensing Process Procedure

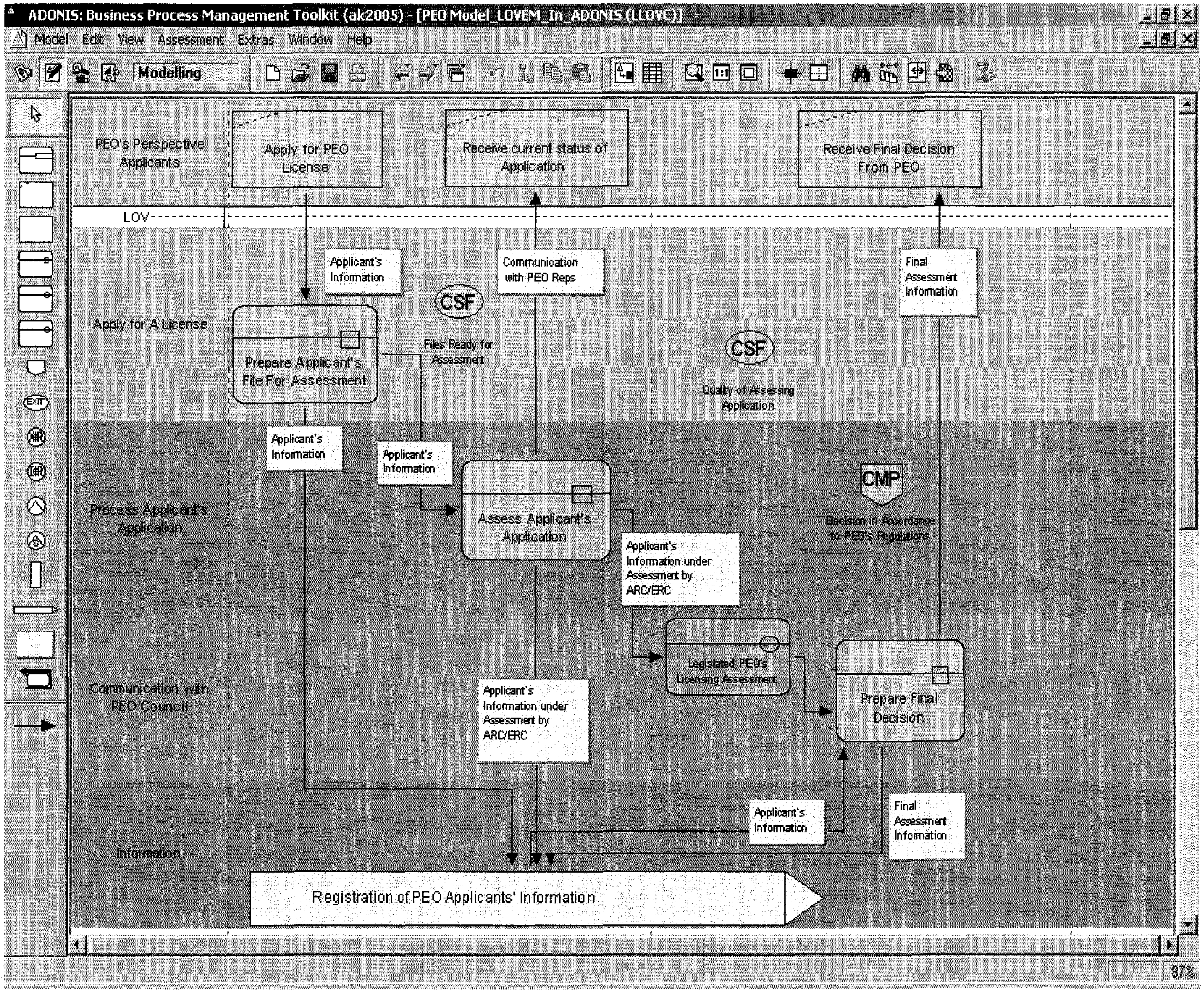


Figure 3.21: The ADONIS - Line Of Visibility Chart Of The PEO's Licensing Procedure

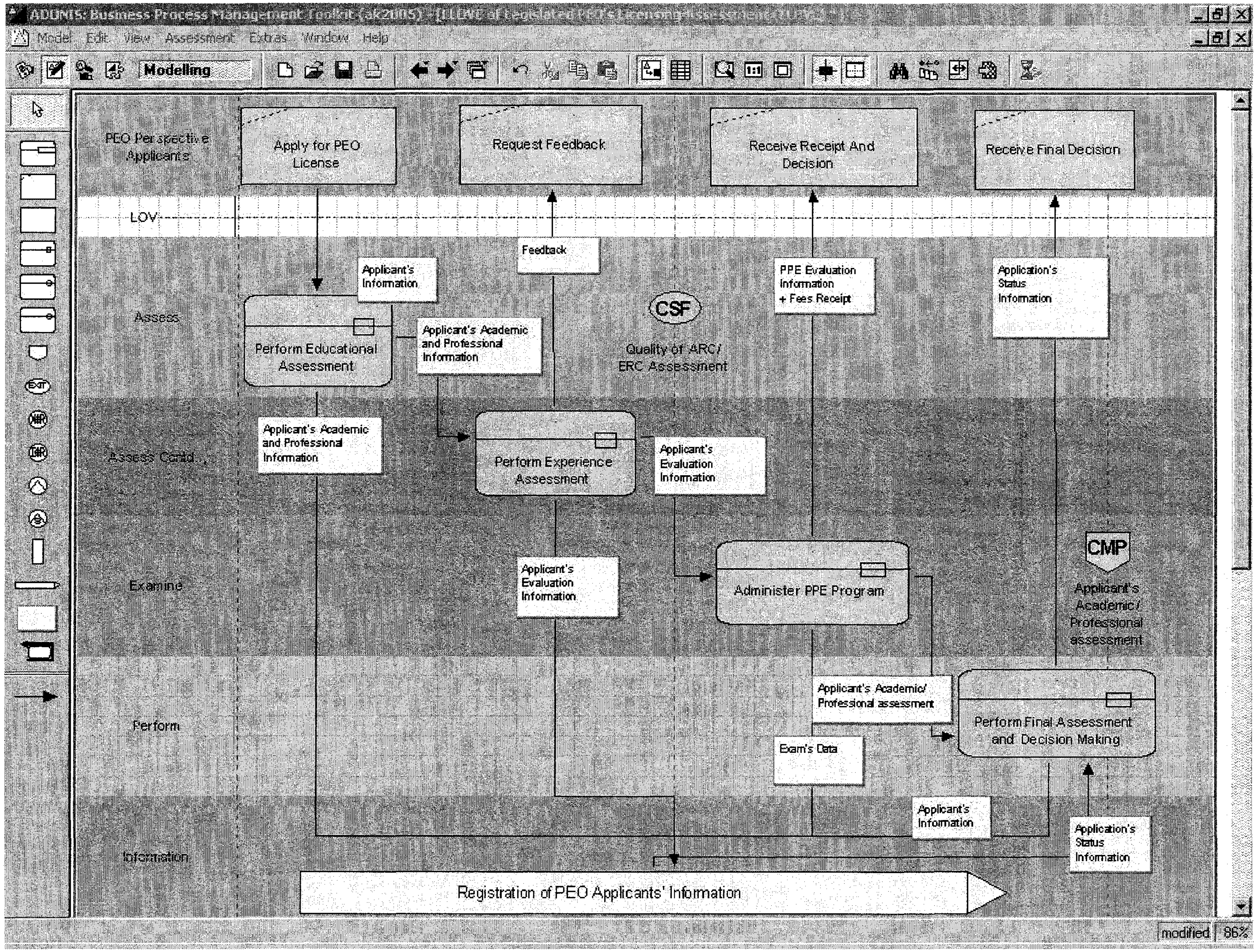


Figure 3.22:The ADONIS – Line Of Visibility Chart Of The Subcomponent Associated With The PEO's Licensing Procedure

3.5 ARIS Representation

3.5.1 Power Point Representation

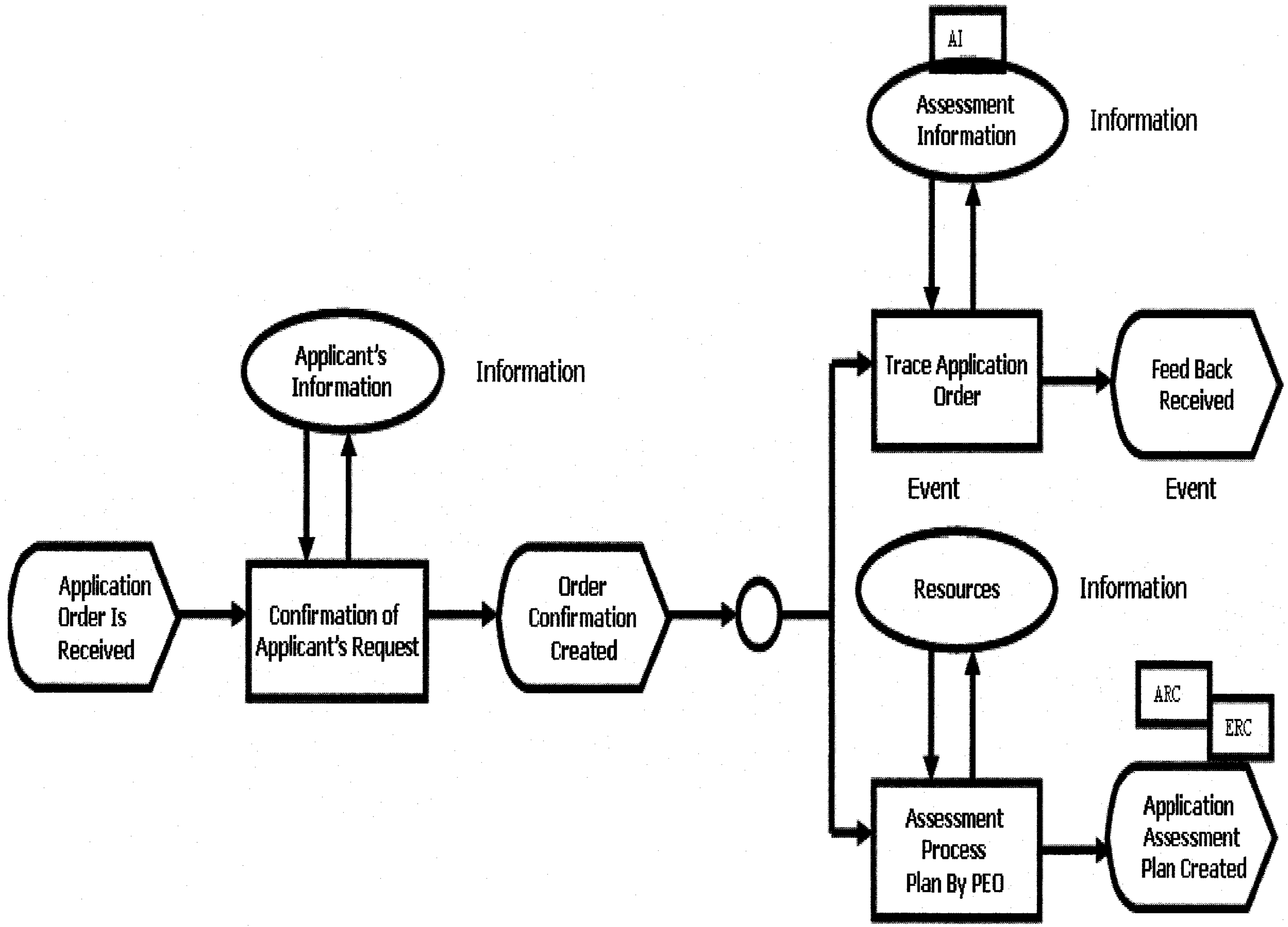


Figure 3.23: ARIS Representation Of The PEO's Information Processing

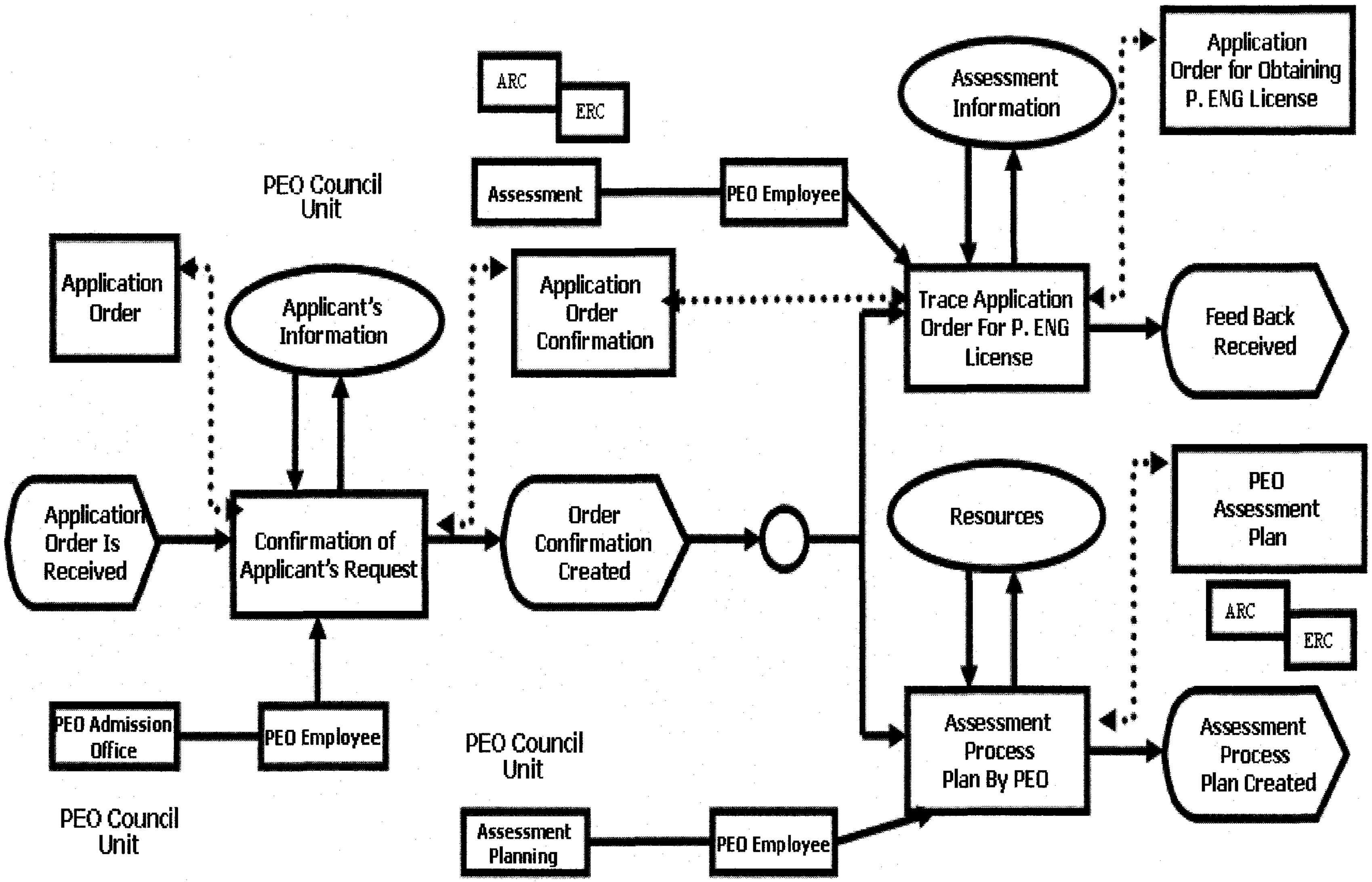


Figure 3.24: ARIS Representation Of The PEO's Function Processing

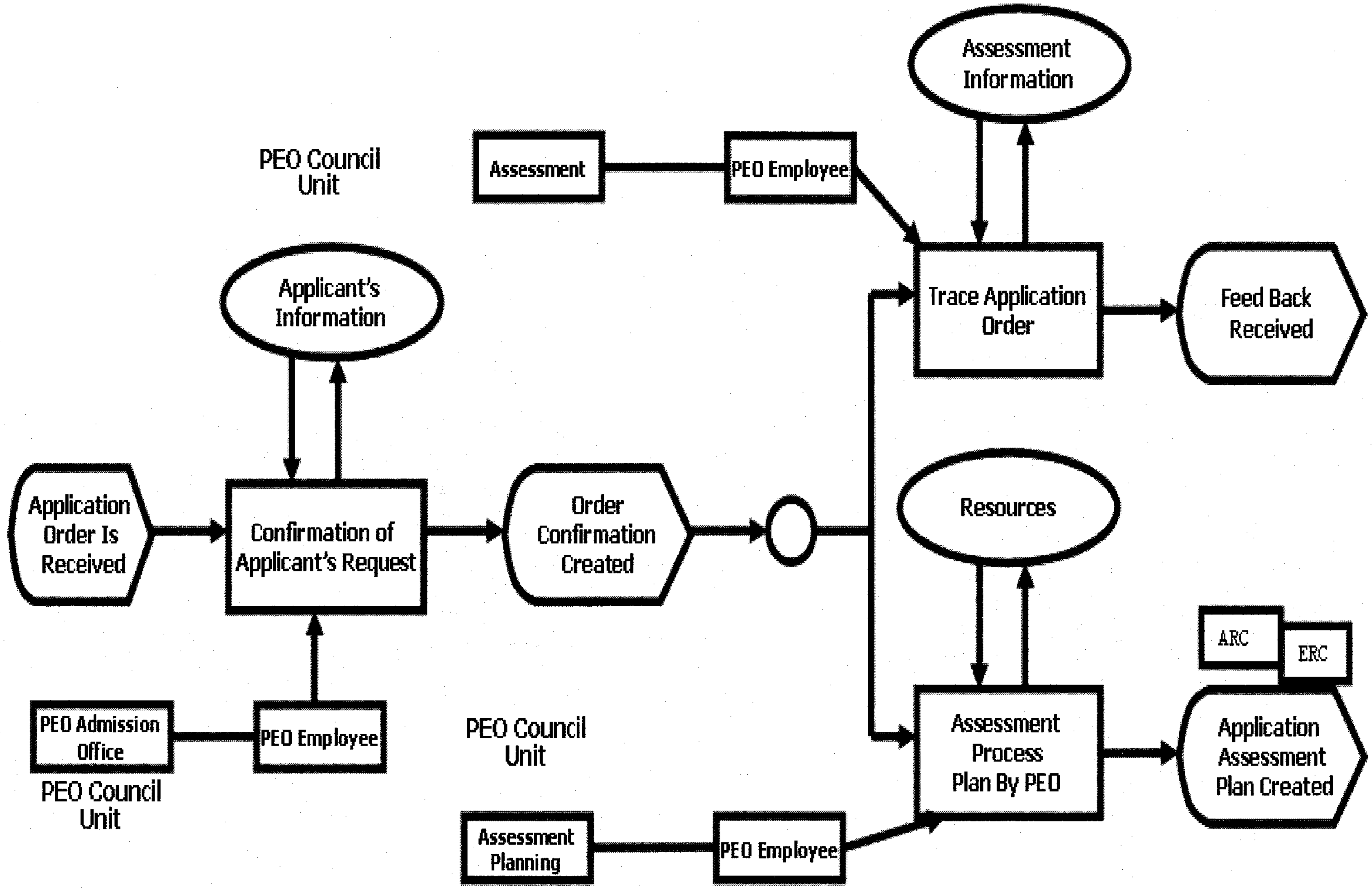


Figure 3.25: ARIS Representation Of Functions Processing By PEO's Employees

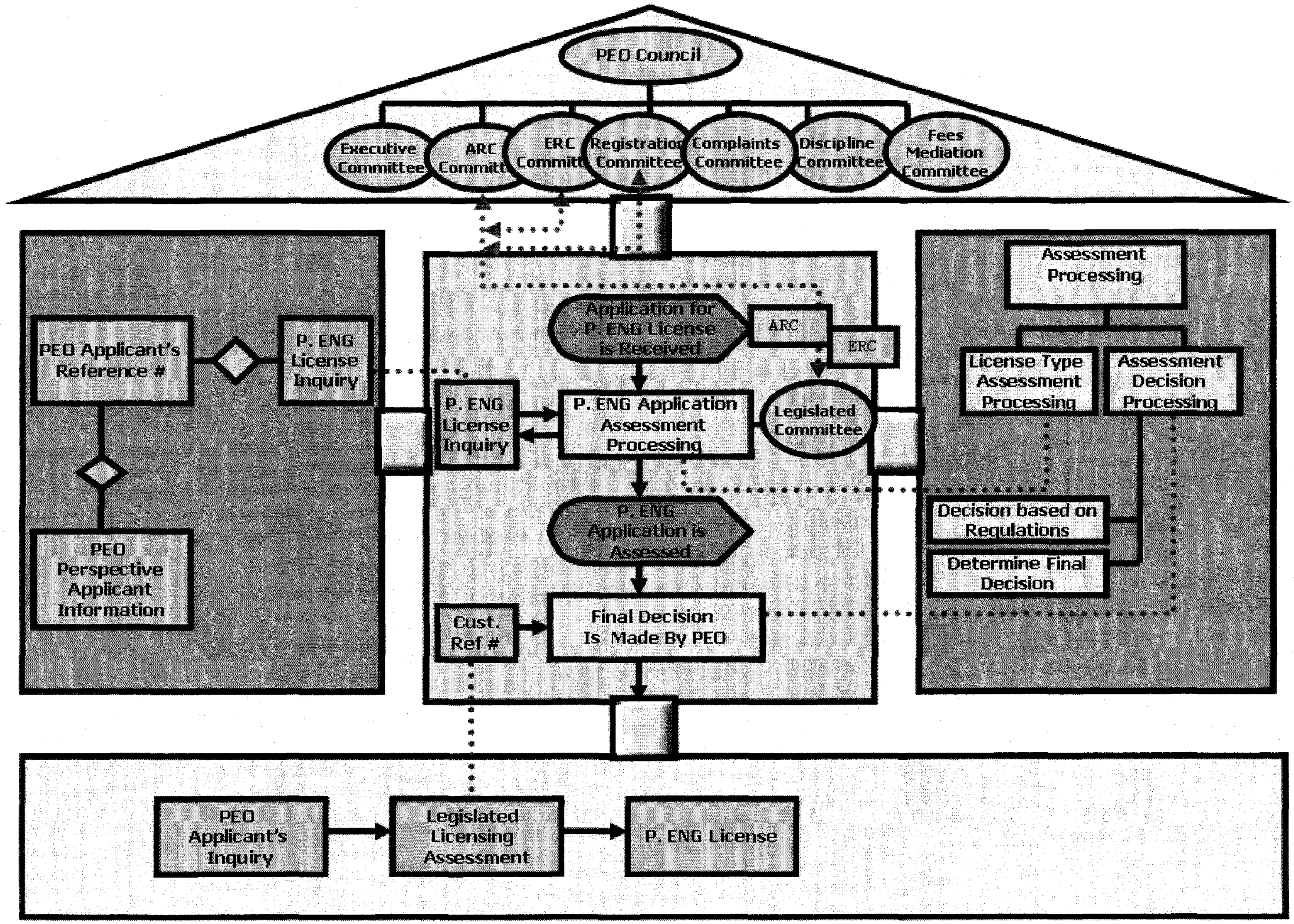


Figure 3.26: General ARIS Framework Representation Of The PEO's Licensing Process

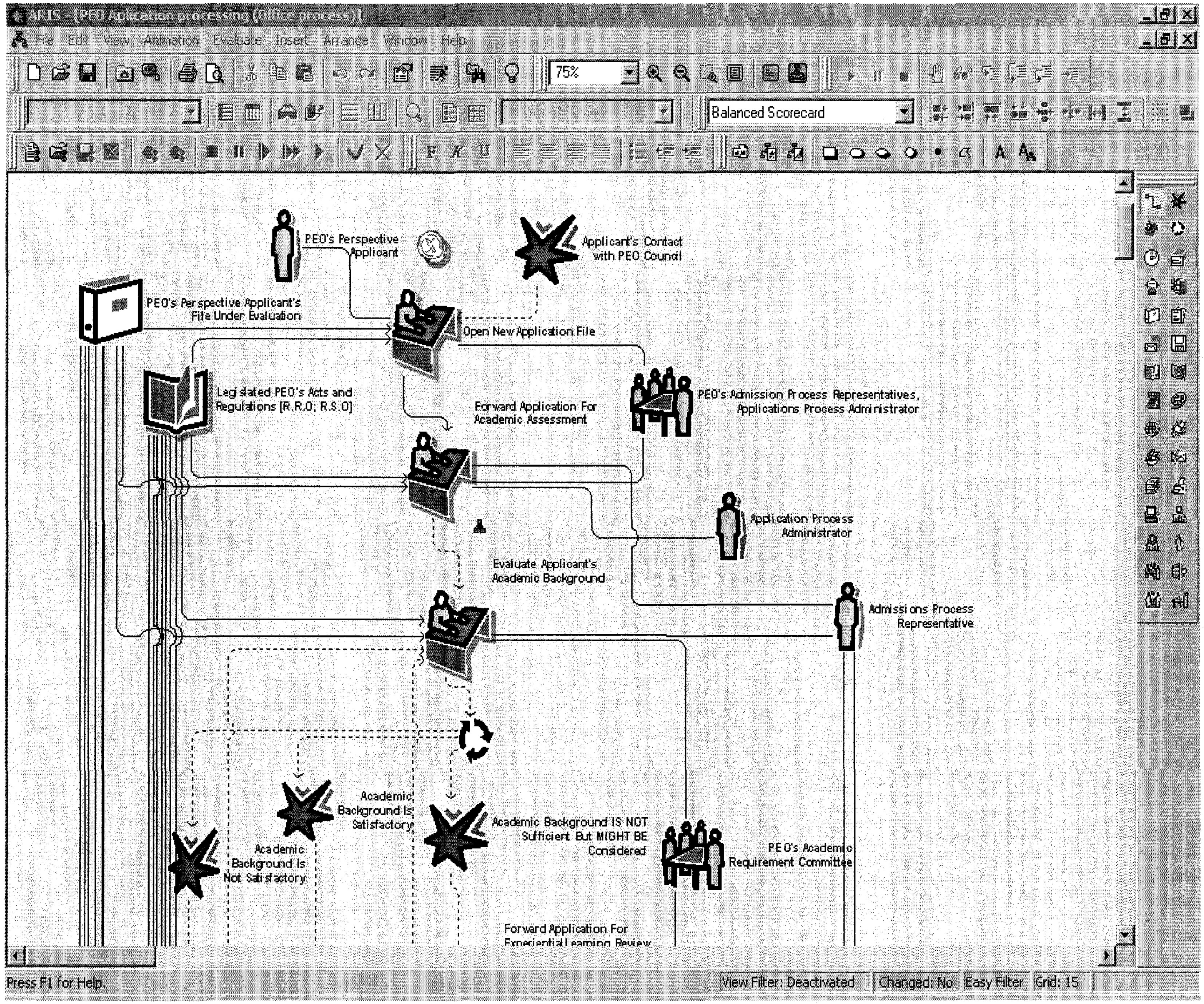


Figure 3.27: ARIS Tool Set Representation Of The PEO's Licensing Processes

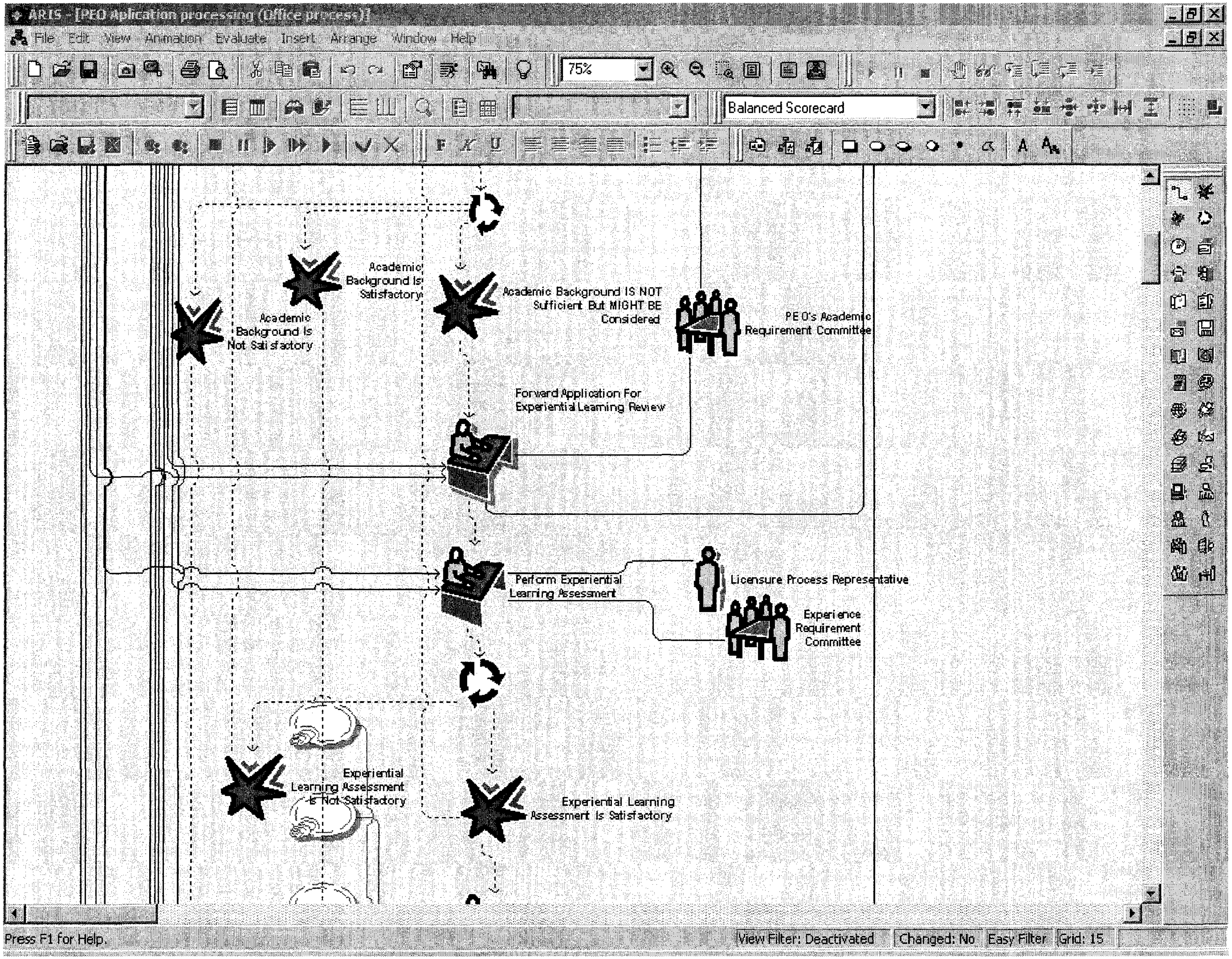


Figure 3.28: Continue ARIS Tool Set Representation Of The PEO's Licensing Processes

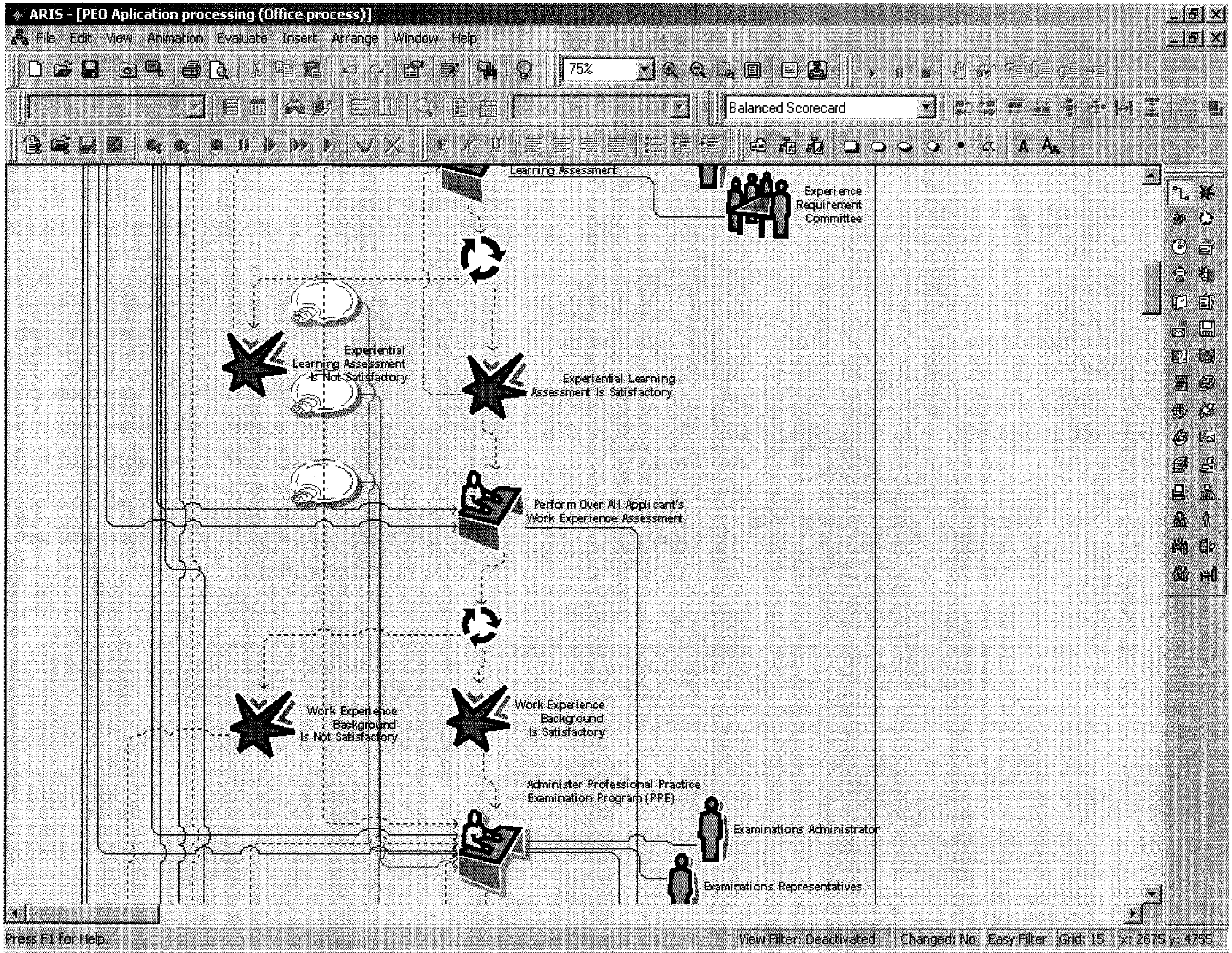


Figure 3.29: Continue ARIS Tool Set Representation Of The PEO's Licensing Processes

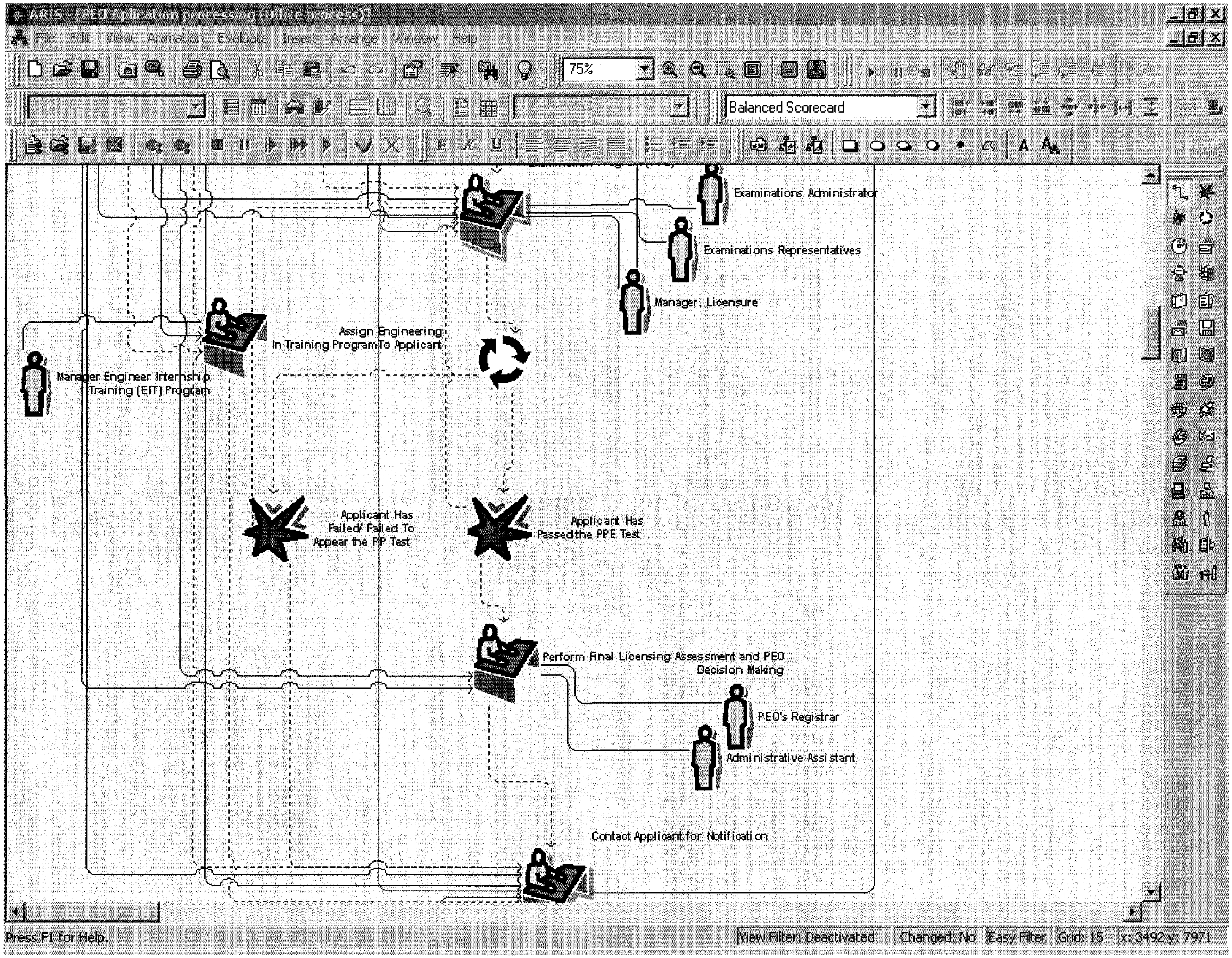


**Figure 3.30: Continue ARIS Tool Set Representation
Of The PEO's Licensing Processes**

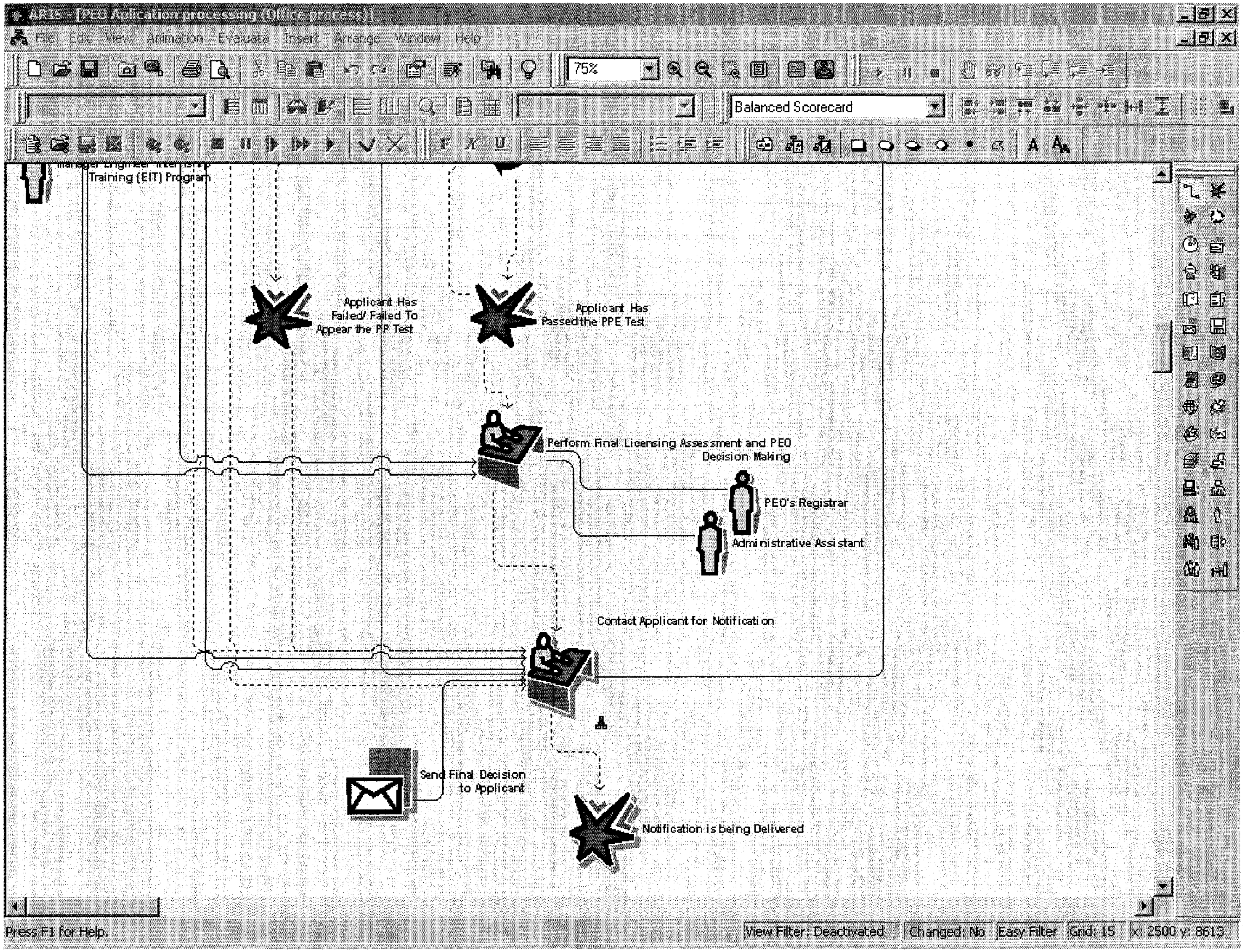


Figure 3.31: Continue ARIS Tool Set Representation Of The PEO's Licensing Processes

3.6 Discussions Of Output of Modelling Methodologies

In this case study, the $IDEF_0$ design methodology has assisted in representing the legislated PEO's licensing processes procedure. It has also assisted to capture and describe the PEO's process details leading to achieve a very rich set of the PEO's process understanding. As mentioned earlier, the $IDEF_0$ is based on structured analysis and design technique that includes both a definition of a graphical modelling language (Syntax and Semantics) and a description of a comprehensive methodology for developing models.

Applying the $IDEF_0$ modelling technique by using the AI0WIN7 tool kit has assisted in representing the PEO's licensing processes procedure. The output of this representation is a model composed of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. There are two primary modelling components used in the PEO's $IDEF_0$ model. The first one is the functions represented on a diagram by boxes. The data and objects that inter-relate those functions are the second one.

In addition, the hierarchical structure of the PEO-$IDEF_0$ model has resulted in quick mapping at a high level. This has been achieved since the PEO's legislated activities have been placed in a left to right sequence within decomposition and connected with the flows. It is natural to order the activities left to right because, if one activity's output is used as input by another activity, drawing the activity boxes and concept connections is clearer. That has enabled to detect one of the $IDEF_0$ capabilities, where sequencing can be embedded in its model. For instance, it has been mentioned earlier that there is a minimum educational level required by the Professional Engineers Act. The $IDEF_0$ modelling language has provided a clear overview of the requirements PEO's perspective applicants need to satisfy based on decomposing particular academic background case. It was stated that if bachelor's degree in engineering has been obtained from a non-CEAB accredited program, applicants' qualifications would be assessed against the CEQB criteria in the specified engineering discipline. This particular case has been well represented in the PEO-$IDEF_0$ model by assigning CEP to give applicants an opportunity to confirm their academic preparation is equivalent or to remedy any identified deficiencies.

Because of the nature of the PEO's processes modelling, the selected $IDEF_0$ modelling language has provided a means for communicating and presenting results. Although it is considered to be implicit and detected by its domain experts, it successfully identified opportunities for improvements and revealing information relationships. That can be explained by its ability of identifying and categorizing information entities, also, producing a structured representation of the PEO's functions, and activities within the modeled system.

Comparing with the traditional flow charting representations demonstrated earlier, the $IDEF_0$ function modelling language was capable of graphically representing a wide variety of the PEO's legislated business together with its entire network communications to any level of detail. The generated model resulted from using the AI0WIN7 tool set has included an entire report based on the selected format (e.g., html format).

The automatically generated report can be considered as a main capability of this tool set. This is because of its ability of linking the input, output, mechanism, and control contents associated with any activity together with its decomposed ones.

In addition, the report generated from the $IDEF_0$ compliant methodology, has the advantage to include any content to be considered as a detailed reference(s) associated with activities representing the PEO's licensing process procedure. The main three references in this case study has been associated with PEO Council [URL: http://www.peo.on.ca/; R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)].

The LOVEM-BPM language can be considered as a subject oriented approach. It has assisted in analyzing and designing the interactions between the PEO's perspective applicants as well as its internal legislated/ administrative business processes. The LOVEM has been implemented in this case study to assist in improving the PEO's business processes. The measuring criteria embedded in this modelling technique targeted the needs and wants based on the PEO's applicants, employee, and legislations to be implemented. Such objective has resulted in determining decision-making criteria for improving PEO's business processes.

Where process sequencing can be embedded in its model, this innovated BPM technique focuses on what the PEO's applicants (Upper Eye) want while they are monitoring their involvement in the associated P. Eng licensing process. Adding to the fact that the LOVEM has successfully assisted in graphically representing the PEO's legislated licensing process, its main subjective output can potentially improve the PEO's council productivity; increase legislators; employees and applicant's satisfaction. For instance, the PEO council can detect and determine where assigned budget for certain processes delays can be reallocated to improve its performance. Where this specific capability has been implicitly demonstrated in the others selected BPM methodologies, the LOVEM has explicitly provided means for selecting potential candidates for fulfilling the requirements to perform the PEO's legislated activities. The PEO-LOVEM model can be considered as an approach to understand the required criteria while selecting perspective PEO's employee.

The ADONIS BPM* tool kit through its BPM component has assisted in graphically modelling the PEO's licensing procedure. In addition, its simulation component has assisted in effectively understanding the sequence of the processes based on the evaluated case the PEO is conducting. Additionally, the simulation component can be used to gain information about the dynamic and quantitative behaviour of the different model fragments [Boucher et al., 2003].

This has been demonstrated in Appendix C. associated with this case study as well as in Appendix D. associated with the automotive manufacturing case study.

In contrast to the so many notations of the PEO-IDEF$_0$ model, the output of the POE-LOVEM model, by using the ADONIS tool kit, has assisted in recognizing in context all PEO's business rules and policies including its CMP, CSF, as well as its GSP. The desired BPI in this work is considered to be subjective and dependent on two main aspects. First, the monitoring eye(s), and the monitored business objectives is second.

The PEO-ARIS model has distinguished between the PEO's council, its function, information and process's views. The output of this model has provided a well-documented methodological framework to enable supporting the entire PEO's council licensing process during its all life cycle phases.

Each of these views in this subject-oriented model has been illustrated and described in different levels of abstraction for the purpose of optimizing the PEO's business processes. Its modelling capability can be explained through its effectiveness in realizing all aspects associated with the PEO's business processes. That has subjectively resulted in an information model that is the keystone for a systematic and intelligent method of developing application systems focusing on improving the PEO's business processes.

A clear justification for deploying the ARIS modelling technique in this case study can be explained in its subjective effectiveness of mastering the complexity of the PEO's business processes while licensing decision-making.

That is accompanied with inconsistency and uncertainty in how precisely such model should be developed then modified. Representing the PEO's legislated licensing processes and structures using the ARIS modelling technique by using the ARIS tool set, has assisted in developing and analyzing the PEO's resulted mode.

The ARIS report has been automatically generated as a result of the PEO-ARIS model as illustrated in Appendix A. the resulted report has successfully included all functions and activities included in the process beside information processed within specific organization of the PEO's council. Working on the ARIS tool set has justified its compliance and compatibility of its main approach. Moreover, its animation part (Single automatic/ automatic animation) has played a major rule in understanding and detecting delays that might result while performing the legislated applications' evaluation.

This is dependent on the business case environment, for determining the function's average waiting time, average orientation time, average processing time. That also includes total cost associated with each activity the PEO processes while evaluating the PEO's perspective applicants' academic and experiential credentials for determining their eligibility of being certified as (P. ENG's).

CHAPTER 4

AUTOMOTIVE MANUFACTURING PROCESSES MODELLING CASE STUDY

4.1 Background

For many years, airplane crash investigators have had the benefit of retrieving data from the flight-data recorder. This information has proven invaluable for helping to determine what happened in the critical time before a crash.

In 1997, the National Transportation Safety Board (NTSB) made the recommendation that vehicle manufacturers and the National Highway Traffic Safety Administration (NHTSA) work together to gather information on vehicle crashes. The NTSB has recommended using on-board collision sensing and recording devices. As a result, General Motors expanded the data downloaded to permanent memory in the air bag sensing and diagnostic module at deployment or in a near-deployment collision [NHTSA, URL: http://www.nhtsa.dot.gov/; URL: http://www-nrd.nhtsa.dot.gov/edr-site/media.html].

The Crash Data Retrieval System (CDRS) is an innovative hardware and software product. It allows anyone with a computer to download vehicle-specific accident data from General Motors vehicles involved in an air bag-deployment or near-deployment collision. The CDRS collects the information stored on the air bag sensing and diagnostic module. It also interprets relevant portions, and presents it in easy-to-understand graphical and tabular formats. By using a proprietary decoding algorithm, the CDRS is capable to present such information as vehicle speed, engine speed, throttle and break data in one-second increments for the five seconds preceding the crash. This type of information can be useful when combined with a complete reconstruction performed through regular means. [Crash Data Retrieval System, URL: http://www.vetronix.com/ppt/brochures/CDR_Overview.ppt].

The CDRS retrieves data from the computer that runs the air bag system. A small chip exists in this module that holds a very small amount of data in "Hex" format. When data are decoded, it can provide data as to the last five seconds pre-collision. It also provides the first 300 milliseconds post-collision's data. Events that weren't quite severe enough to cause the air bags to deploy are also provided. The CDRS is a simple way to access the information stored on the vehicle's air bag module. This new tool also allows the investigator to input other relevant information, such as weather conditions, and export the data to a remote database.

In this case study, complexity concerns the CDR processes mechanism' including variety of its components and relationships between them has been investigated. The processes' modelling part is intended to examine the CDR's information complexity, their variety and uncertainty in their accuracy, and their usefulness while been used as a legal evidence.

4.2 Process Flow Charting

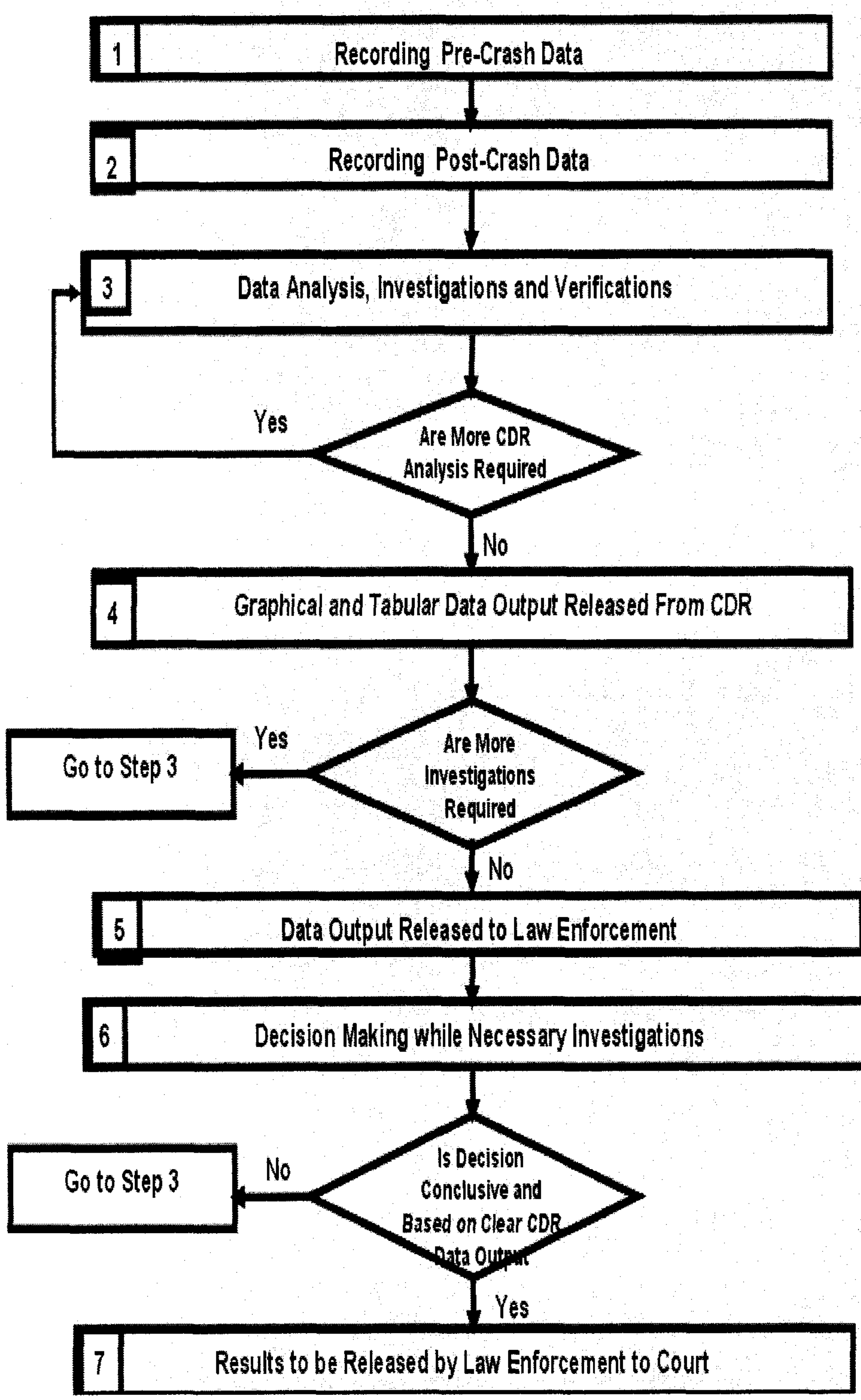


Figure 4.1 Flow Chart Of The Automobile's Crash Data Retrieval System

4.3 IDEF$_0$ Representation

4.3.1 Power Point Representation

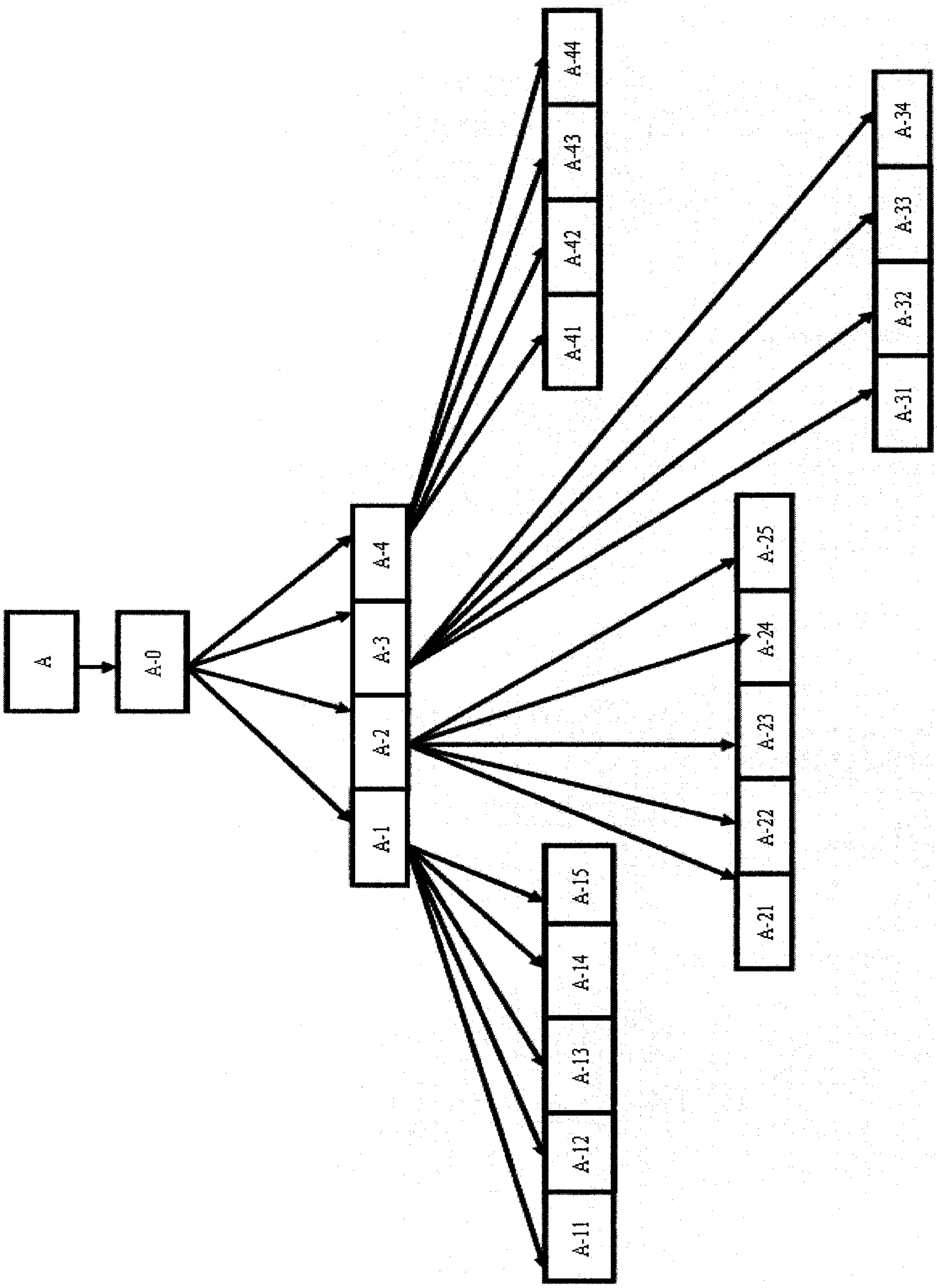


Figure 4.2: IDEF$_0$ Power Point Representation Of the Expanded Tree Diagram Of The Automobile's Crash Data Retrieval System

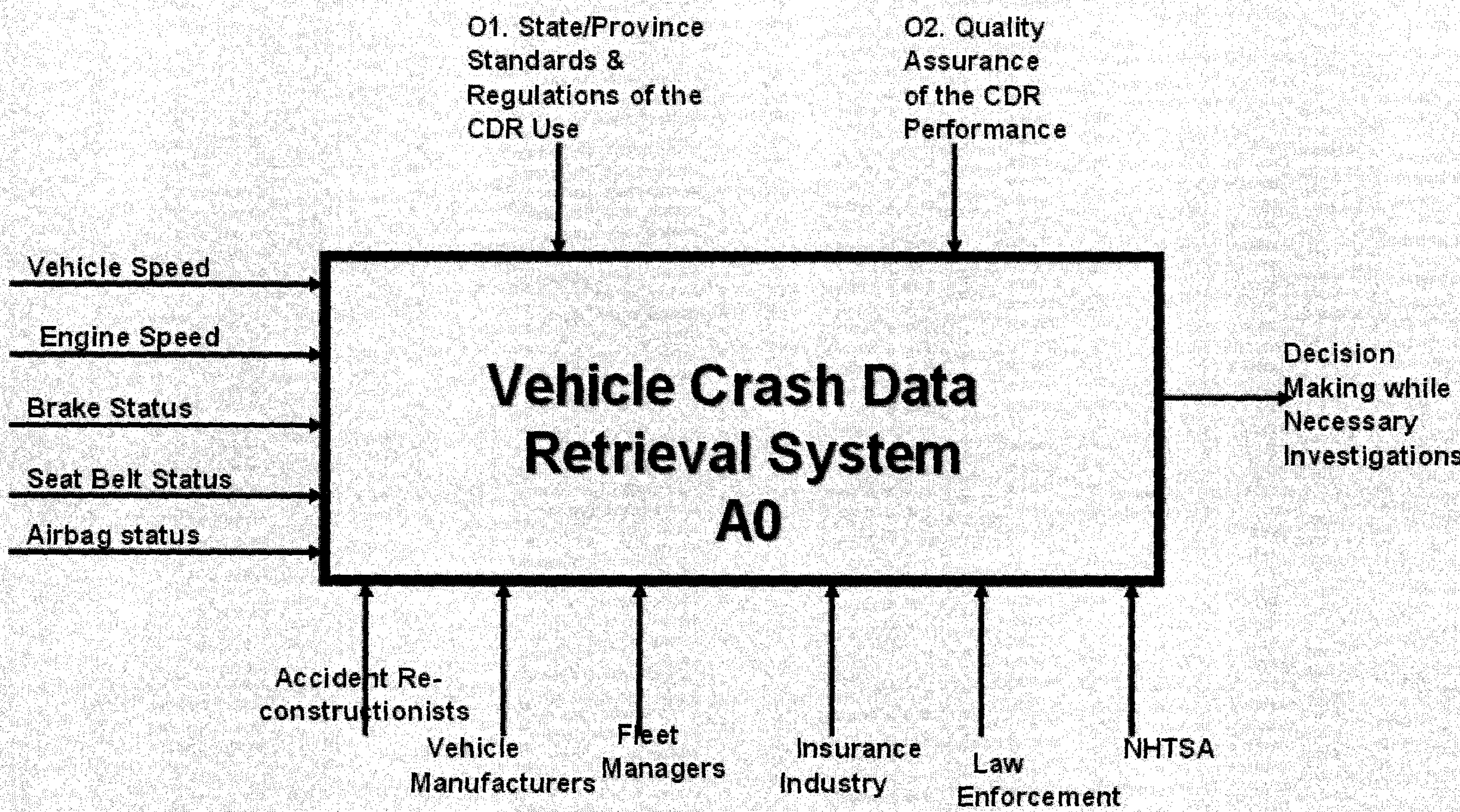


Figure 4.3: IDEF$_0$ Power Point Representation Of The Automobile's Crash Data Retrieval System (A0)

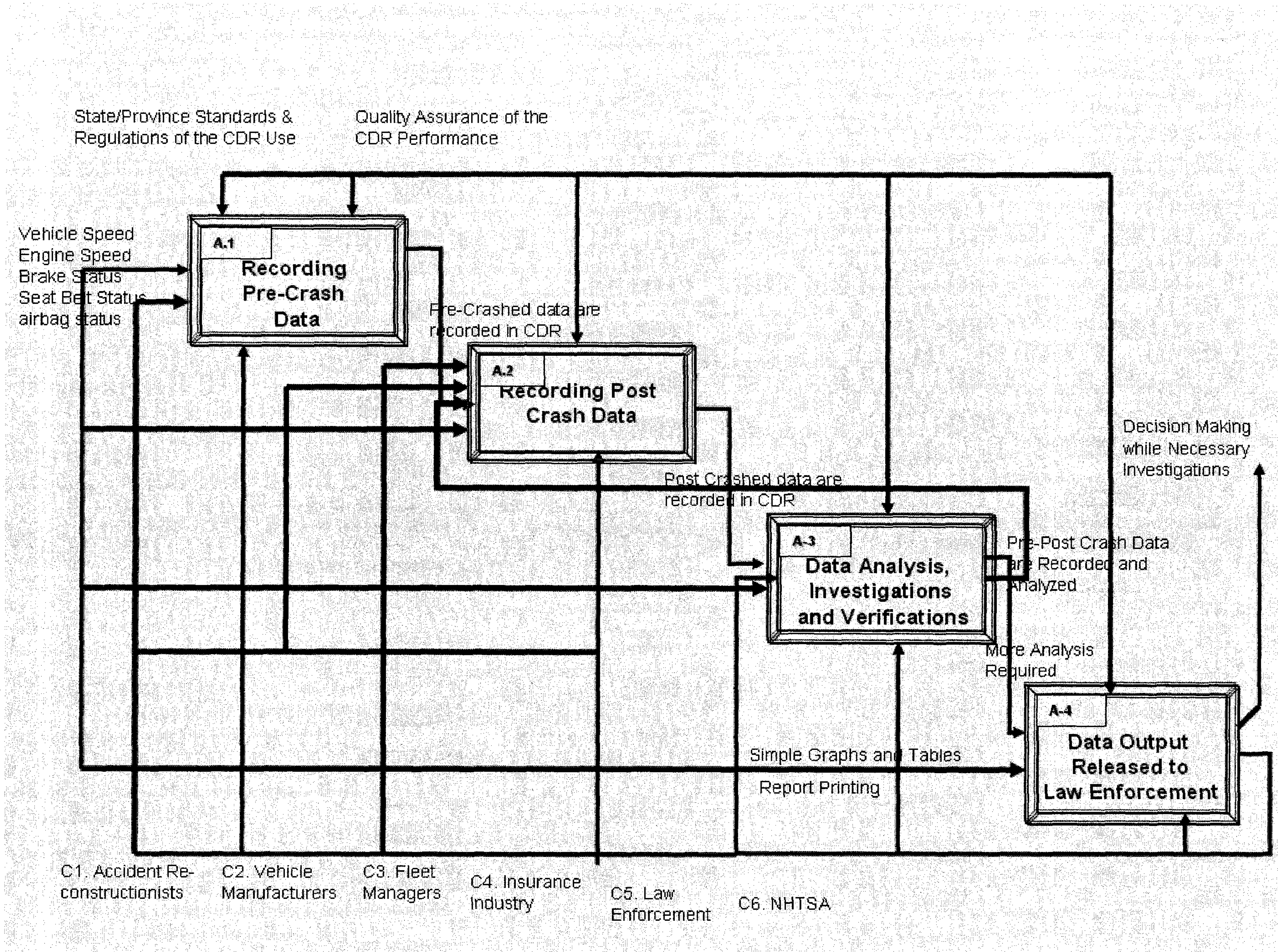


Figure 4.4 : IDEF$_0$ Power Point Representation Of The Automobile's Crash Data Retrieval System (A0 Decomposition)

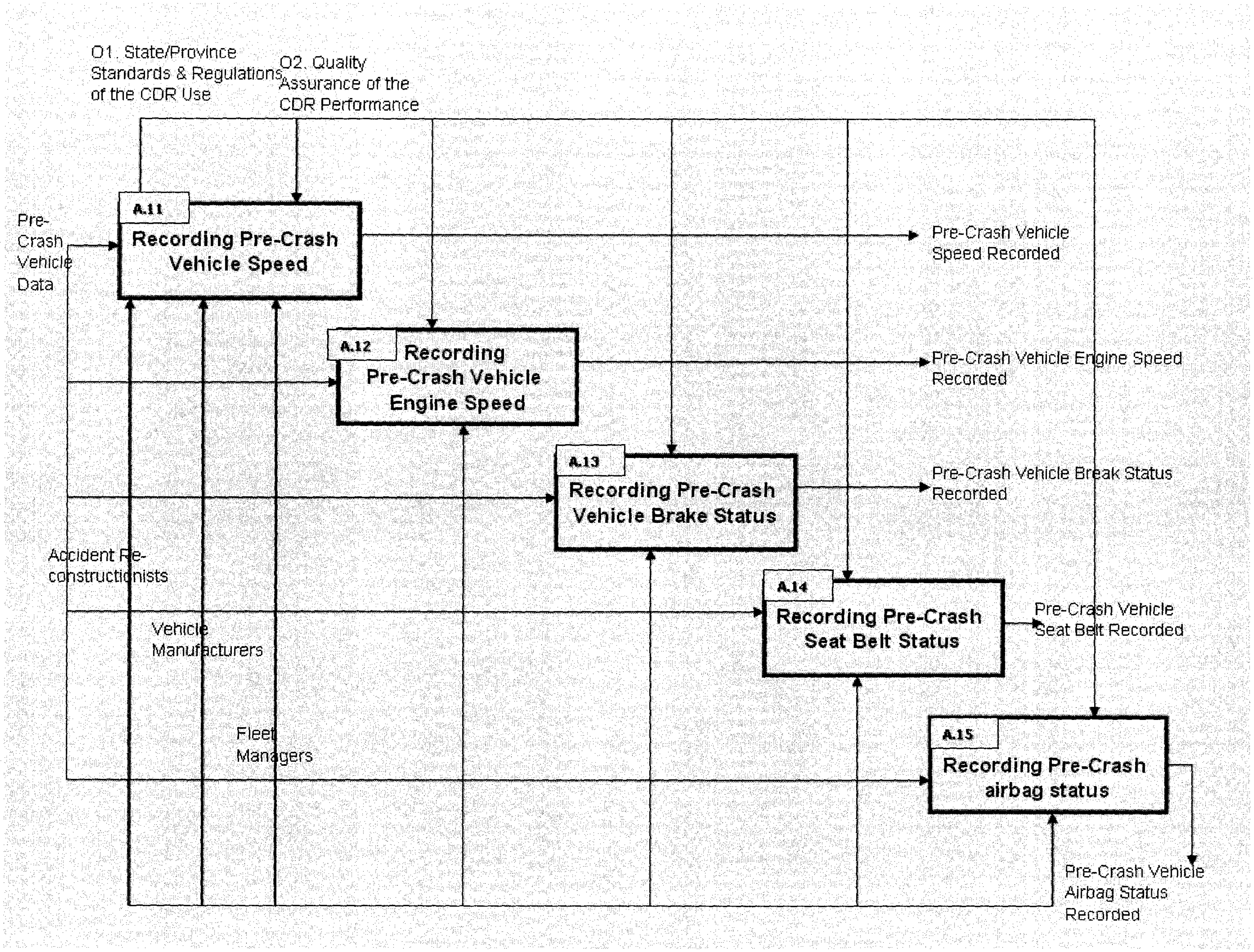


Figure 4.5 : IDEF$_0$ Power Point Representation Of The Decomposition Of A1: Recording Pre-Crash Data

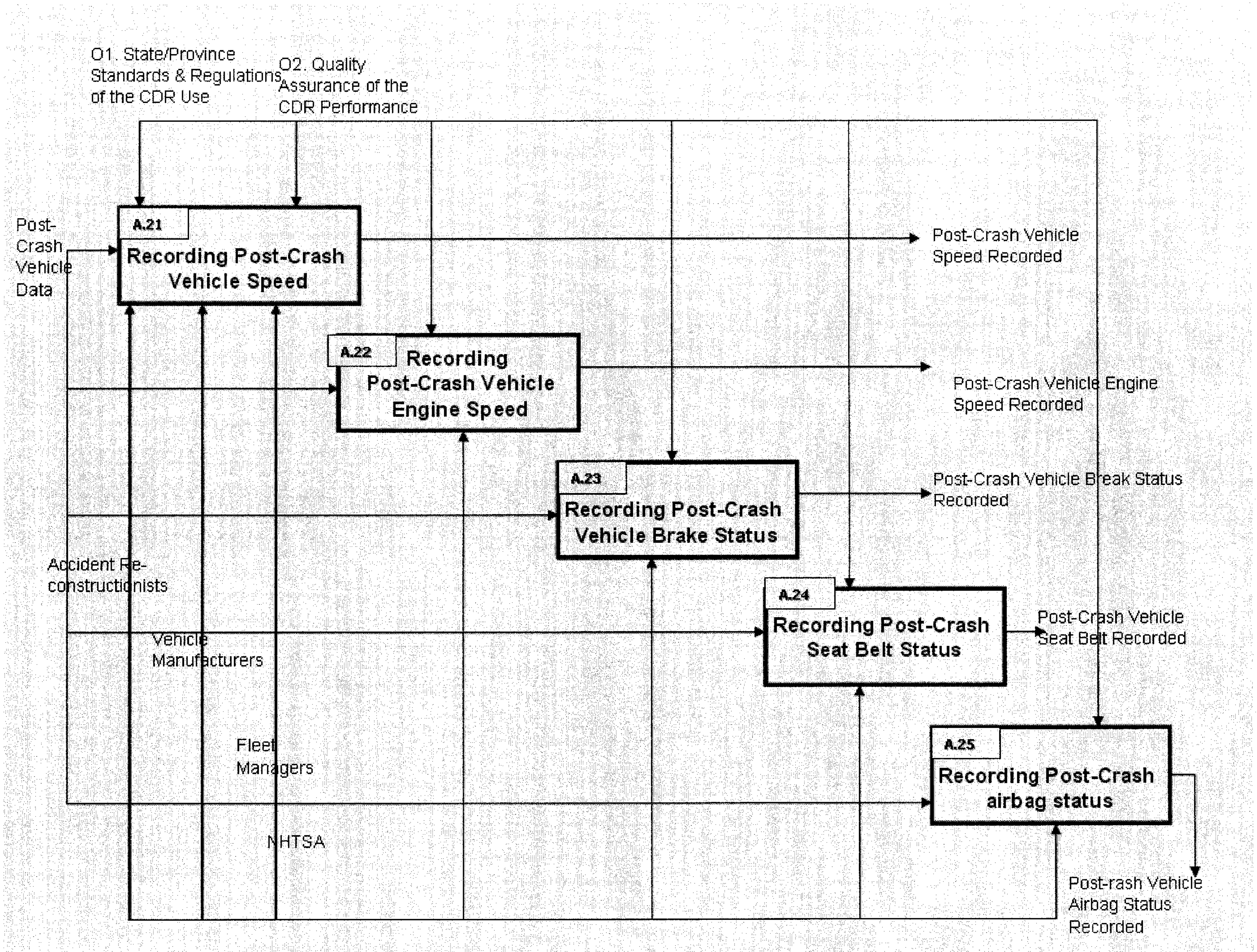


Figure 4.6 : IDEF$_0$ Power Point Representation Of The Decomposition Of A2: Recording Post-Crash Data

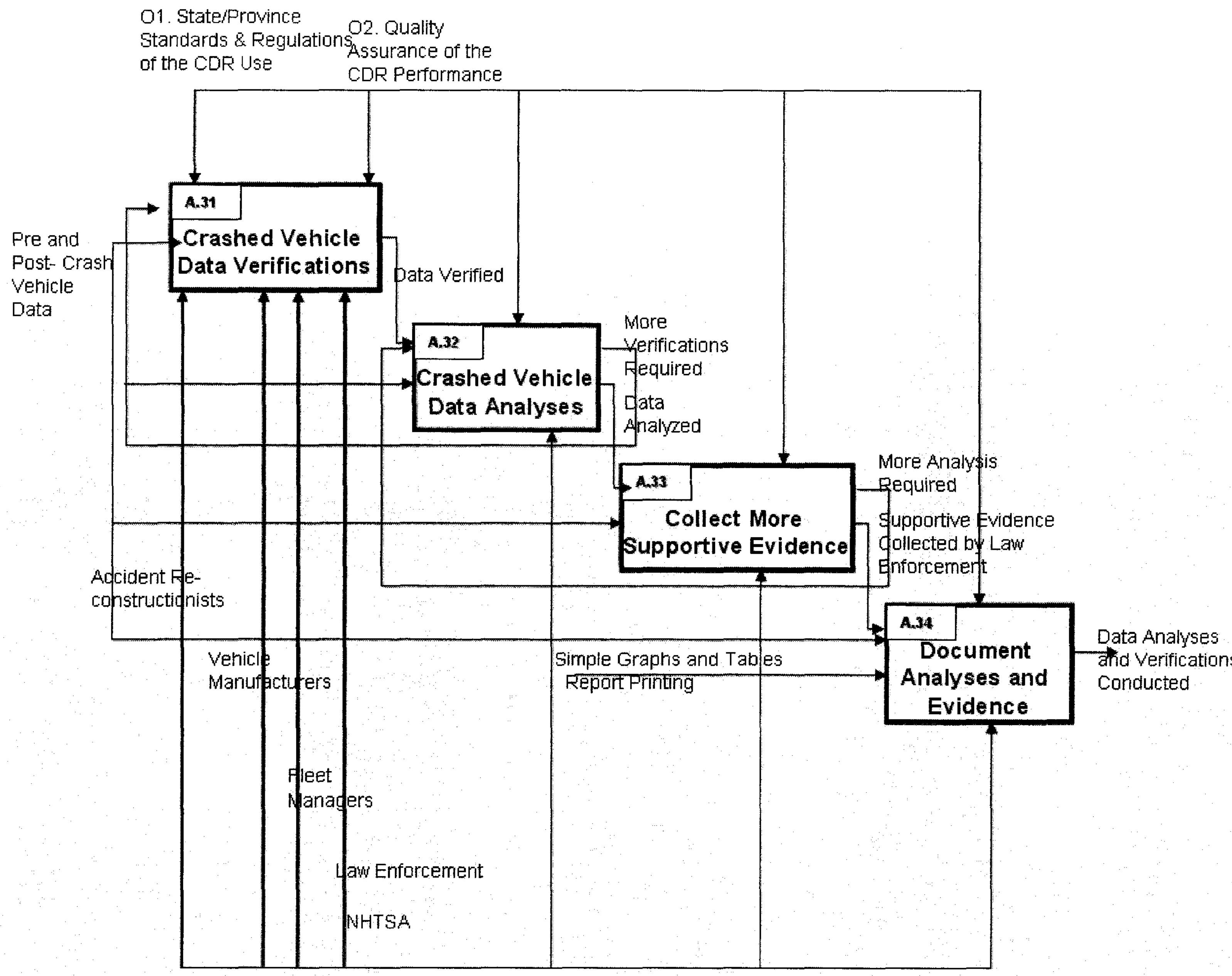


Figure 4.7 : IDEF$_0$ Power Point Representation Of The Decomposition Of A3: Data Analysis Investigations and Verifications

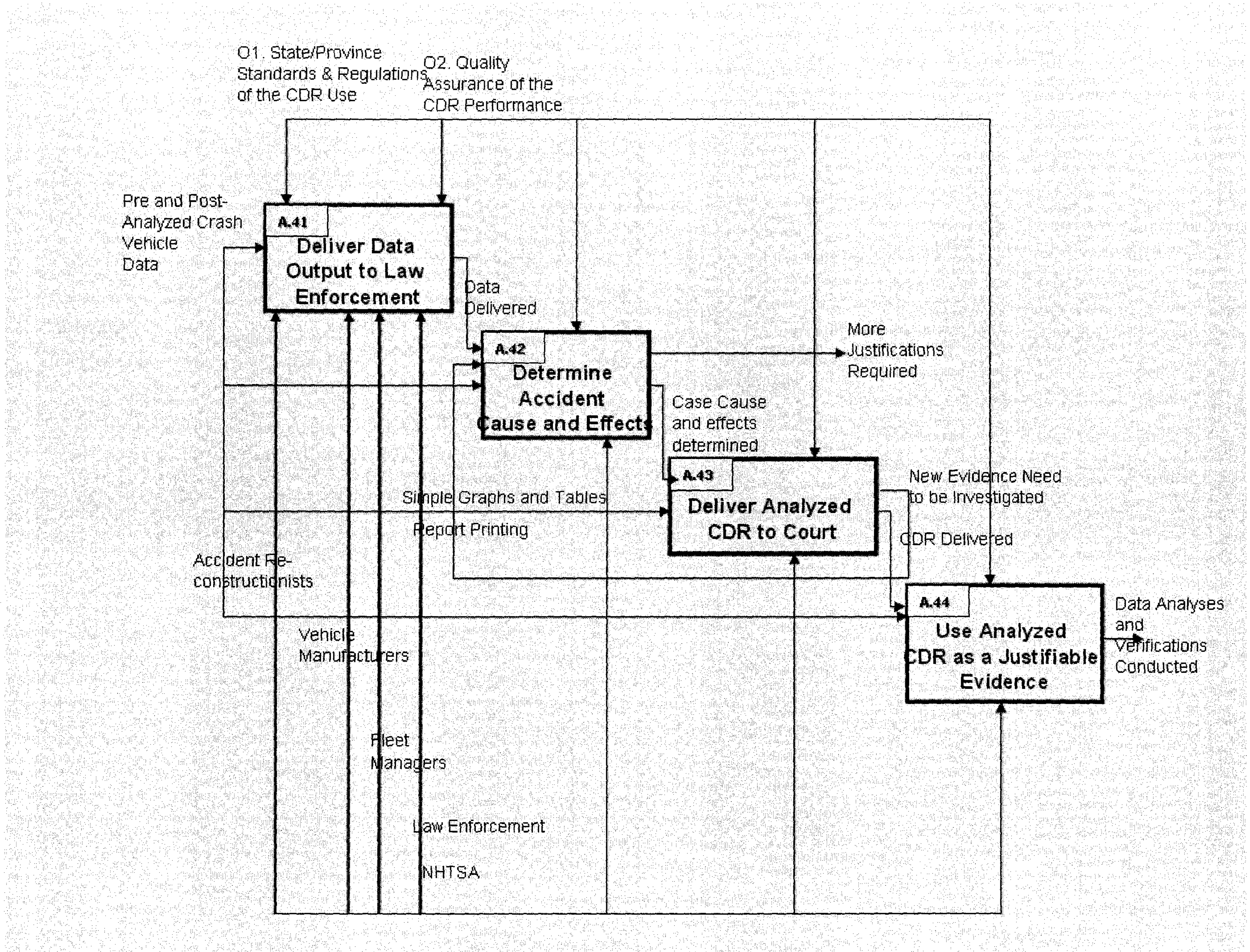


Figure 4.8 : IDEF$_0$ Power Point Representation Of The Decomposition Of A4: Data Output Released to Law Enforcement

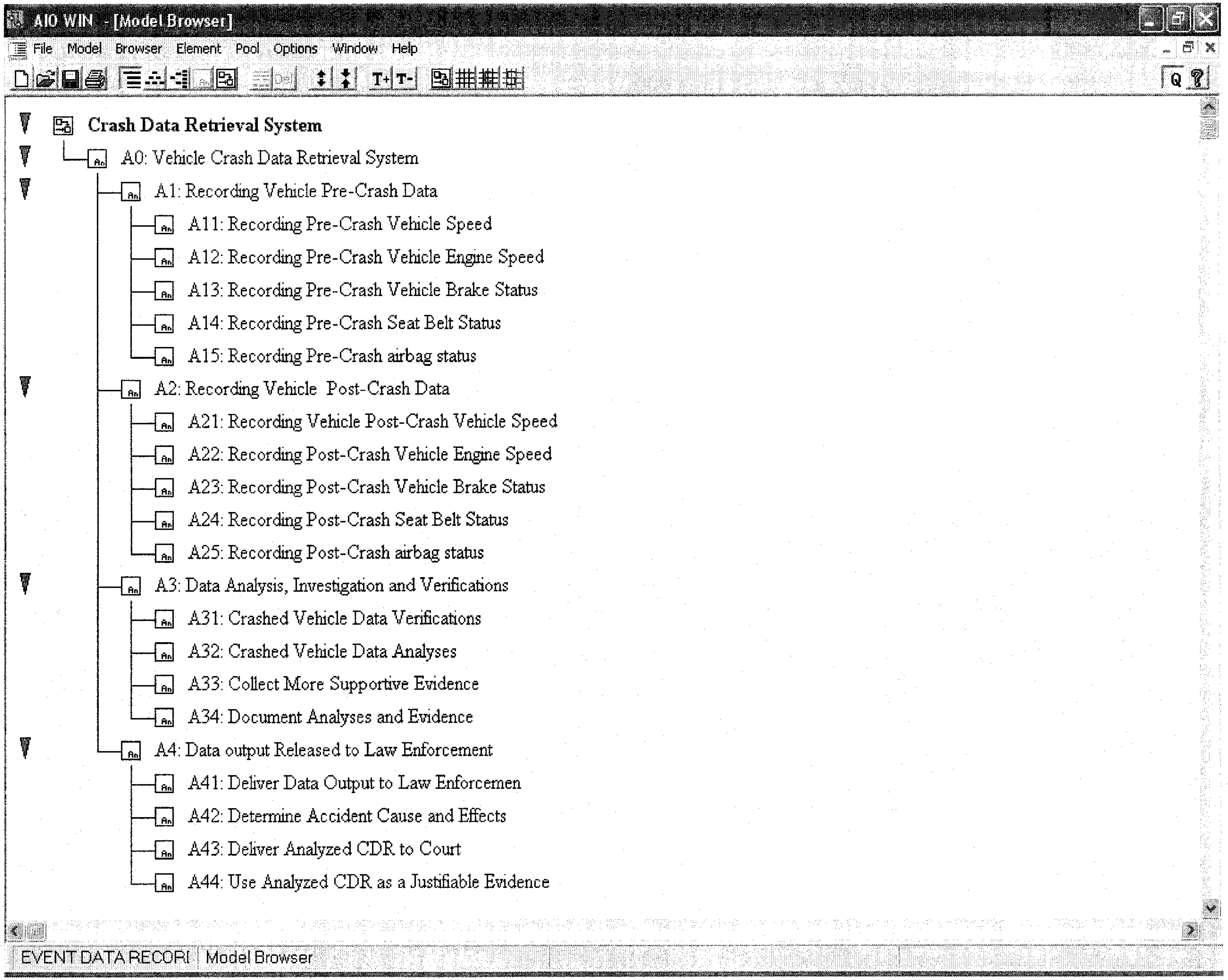


Figure 4.9: IDEF$_0$ AI0WIN7 Representation Of the Expanded Tree Diagram Of The Automobile's Crash Data Retrieval System

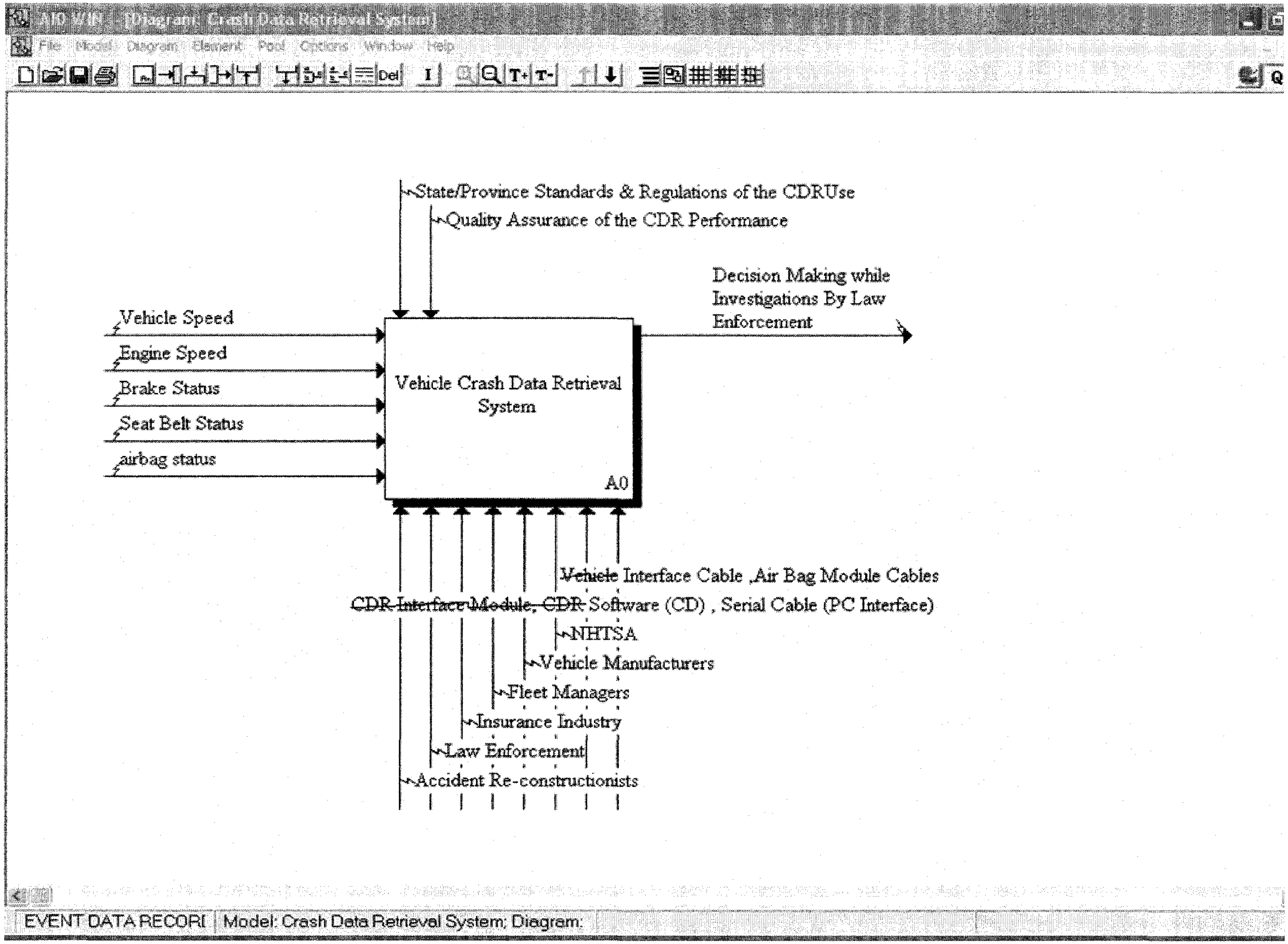


Figure 4.10: IDEF$_0$ AI0WIN7 Representation Of The Automobile's Crash Data Retrieval System (A0)

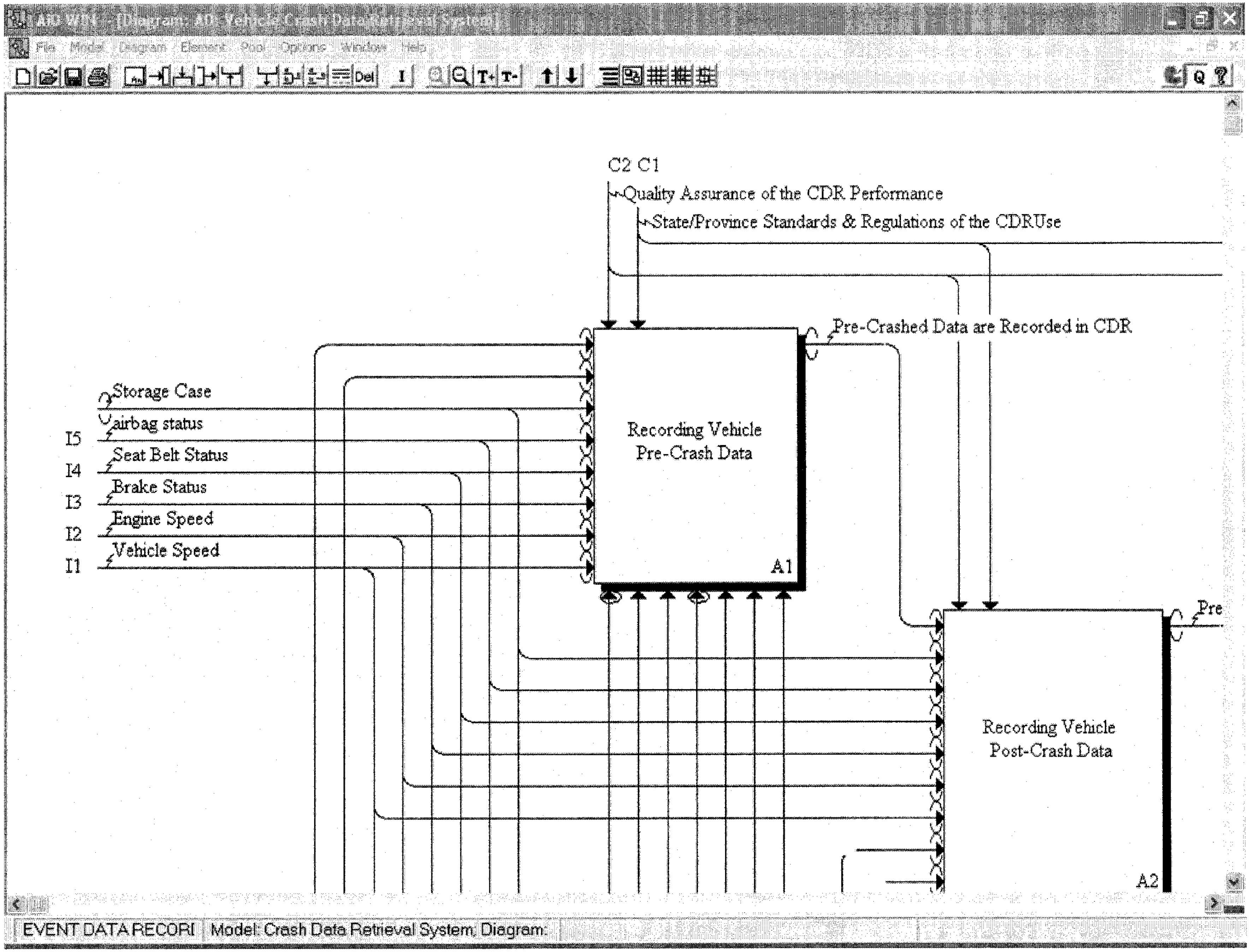


Figure 4.11 : IDEF$_0$ AI0WIN7 Representation Of The Automobile's Crash Data Retrieval System (A0 Decomposition)

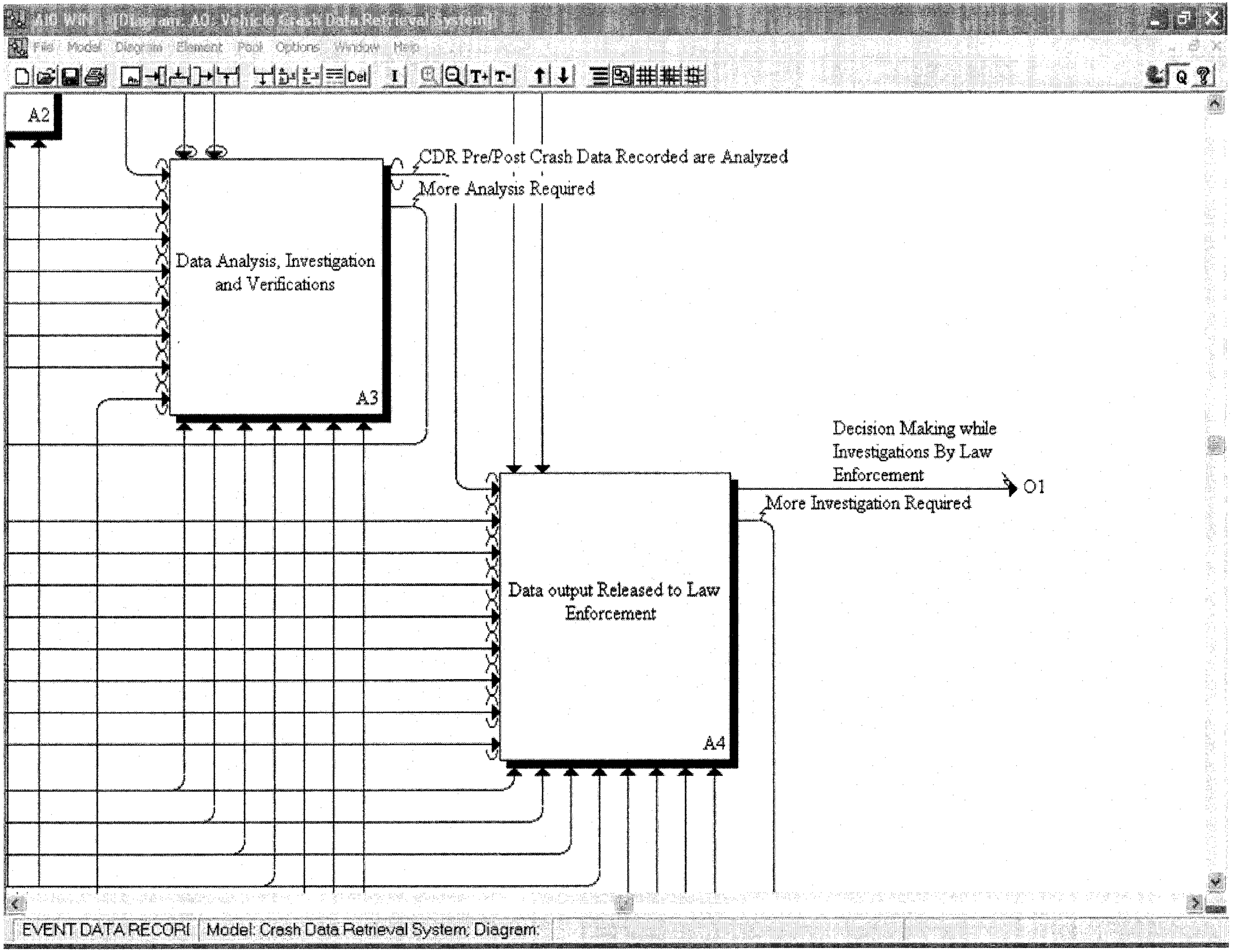


Figure 4.12 : Continue IDEF$_0$ AI0WIN7 Representation Of The Automobile's Crash Data Retrieval System (A0 Decomposition)

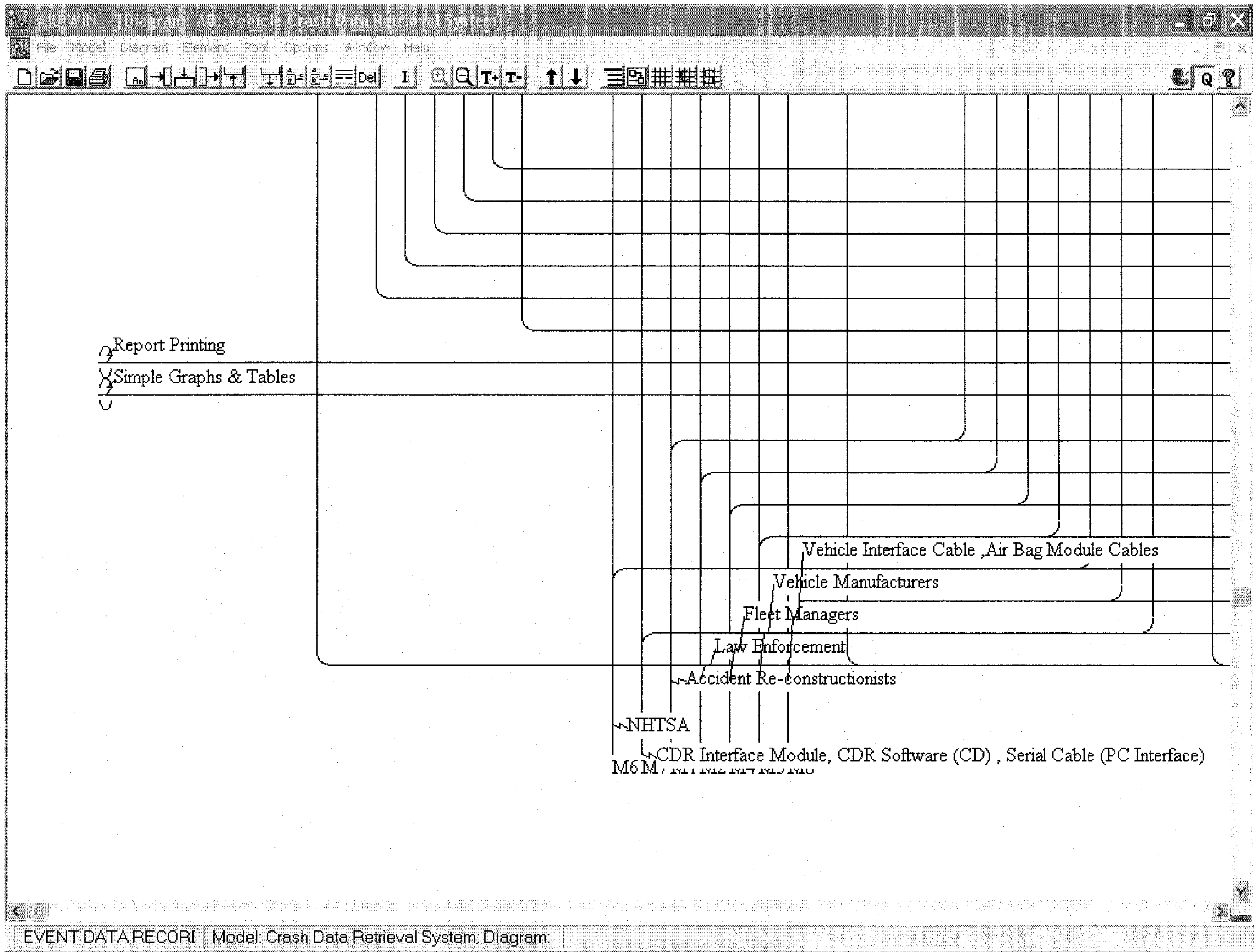


Figure 4.13 : Continue IDEF$_0$ AI0WIN7 Representation Of The Automobile's Crash Data Retrieval System (A0 Decomposition)

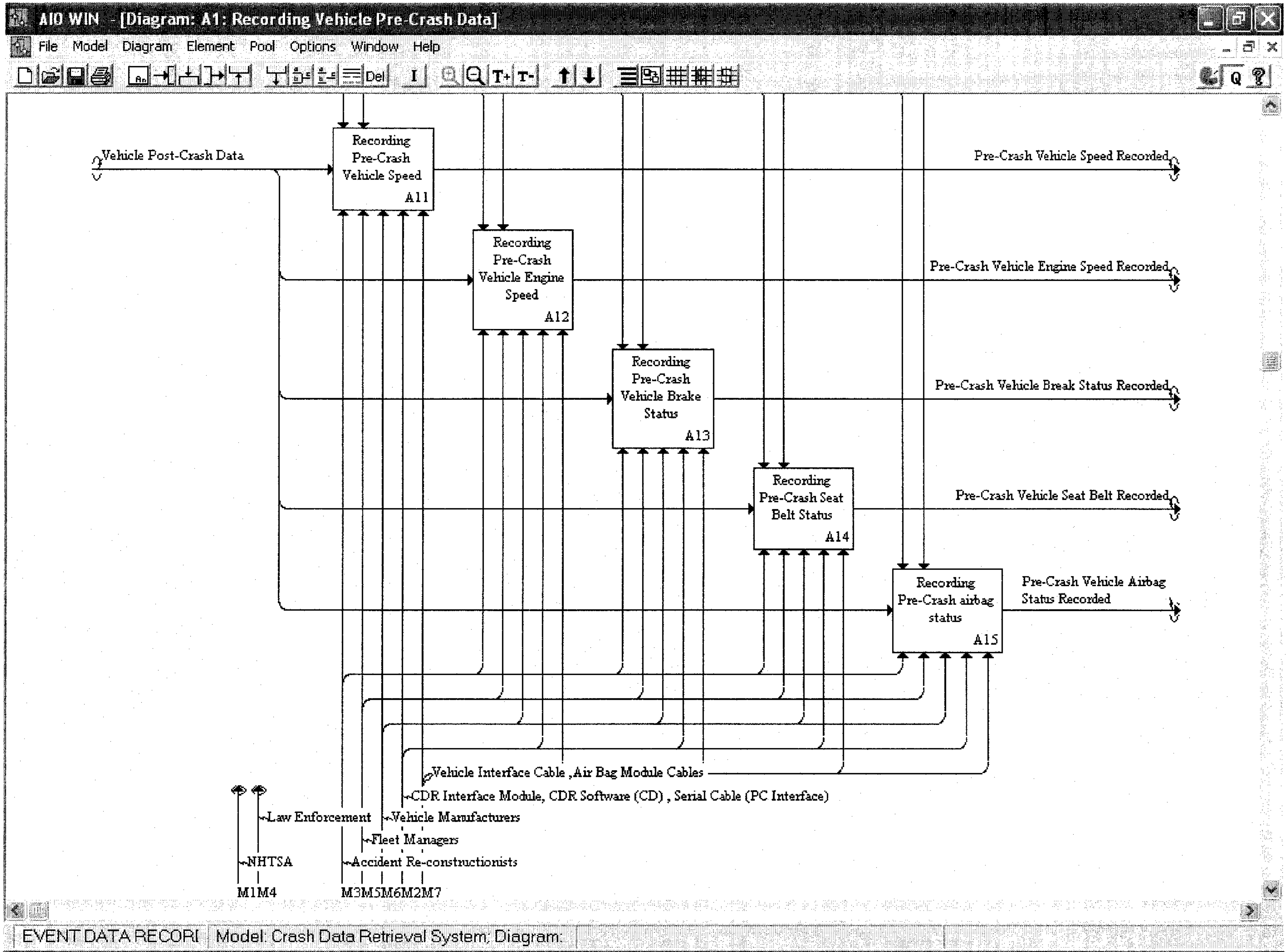


Figure 4.14: IDEF$_0$ AI0WIN7 Representation Of The Decomposition Of A1: Recording Pre-Crash Data

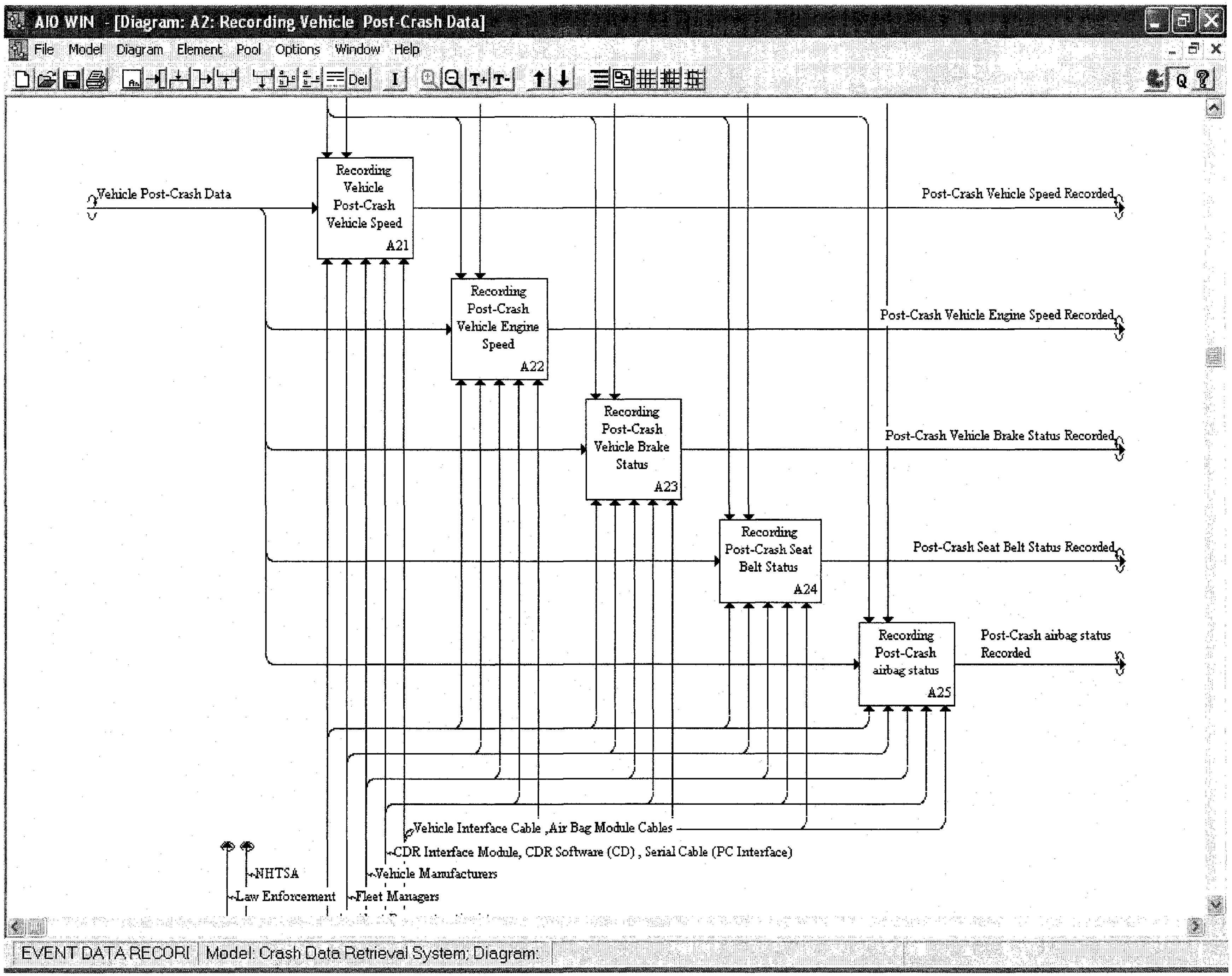


Figure 4.15 : IDEF$_0$ AI0WIN7 Representation Of The Decomposition Of A2: Recording Post-Crash Data

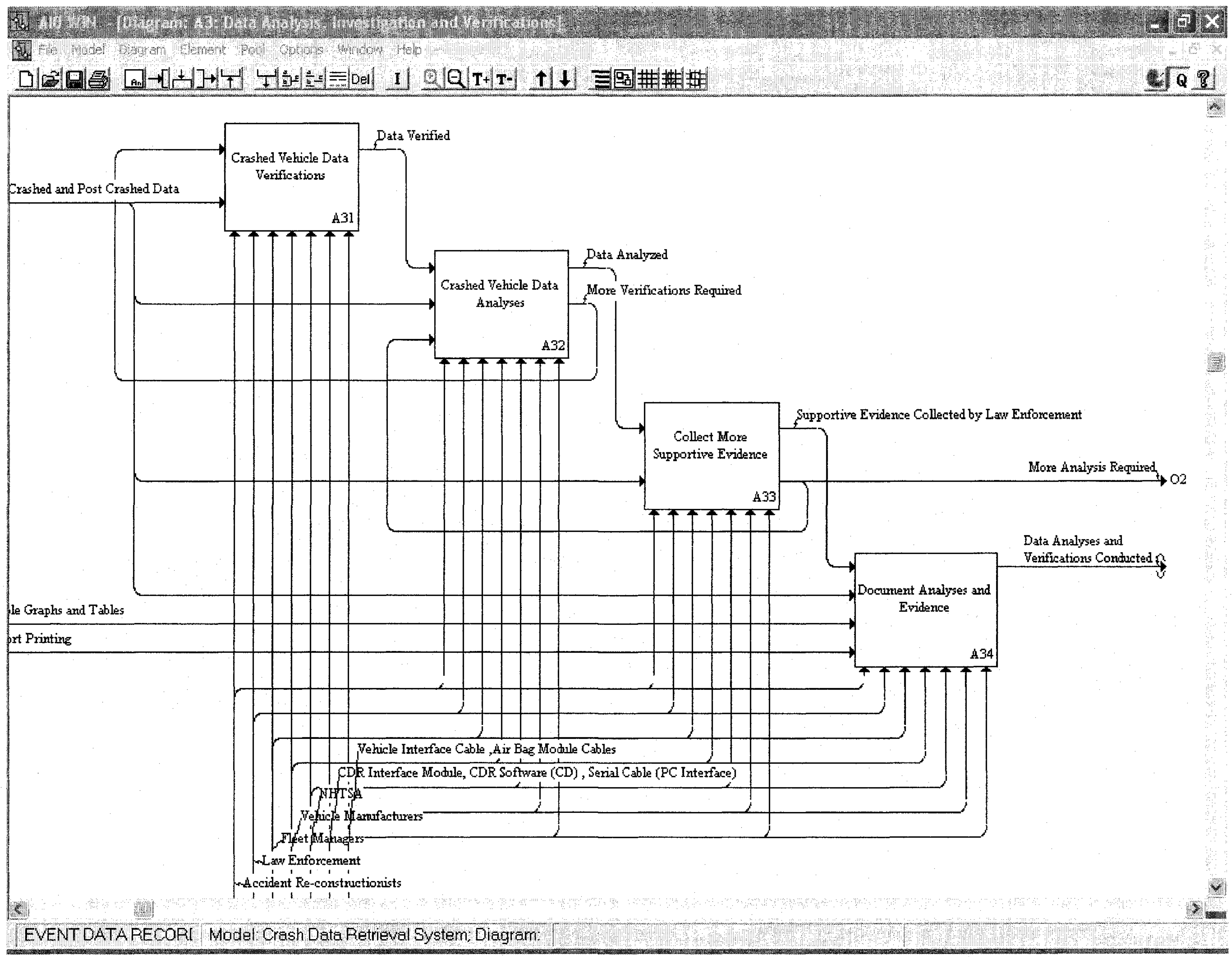


Figure 4.16 : IDEF$_0$ AI0WIN7 Representation Of The Decomposition Of A3: Data Analysis Investigations and Verifications

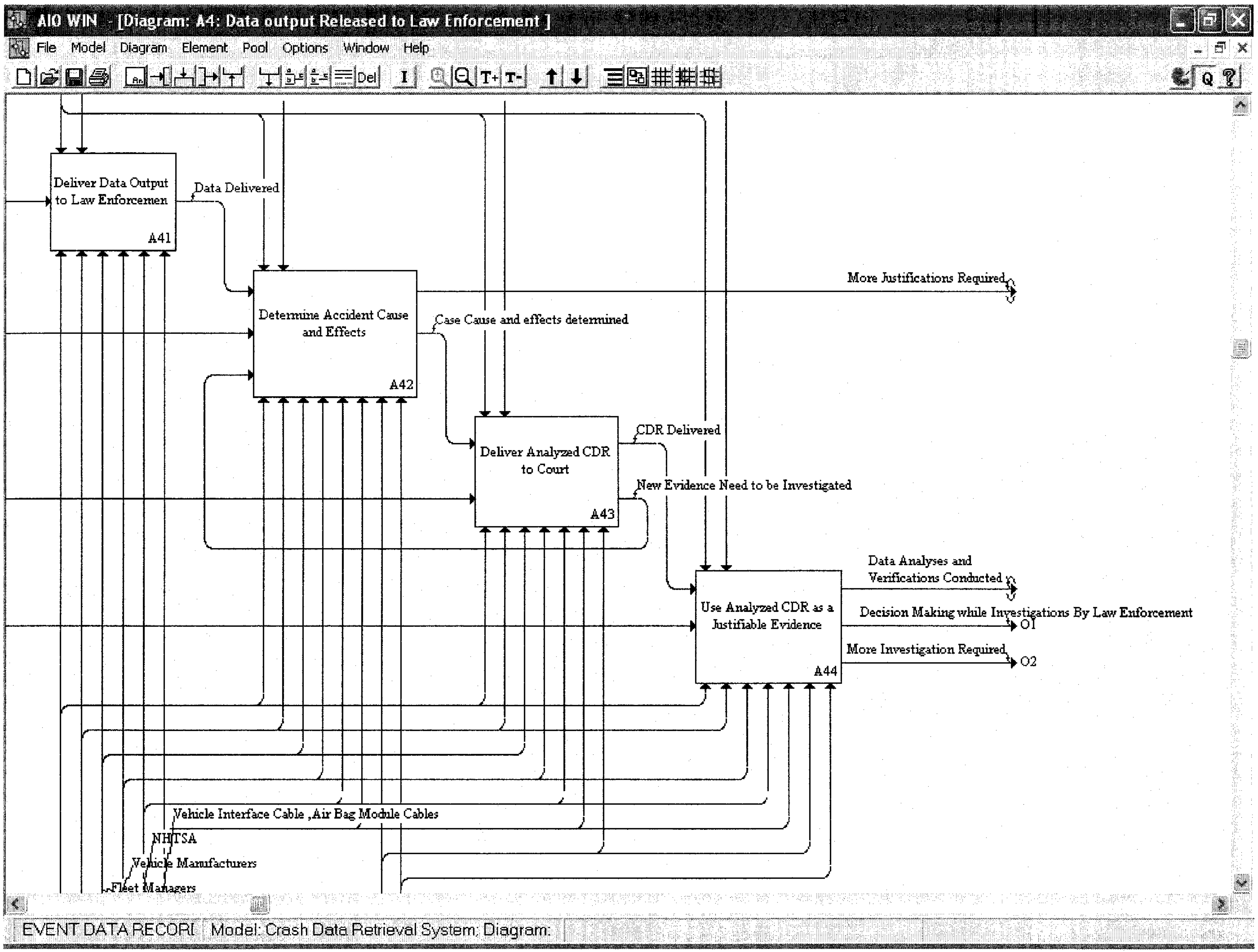


Figure 4.17 : IDEF$_0$ AI0WIN7 Representation Of The Decomposition Of A4: Data Output Released to Law Enforcement

4.4 Line of Visibility Enterprise Modelling Representation

4.4.1 Power Point Representation

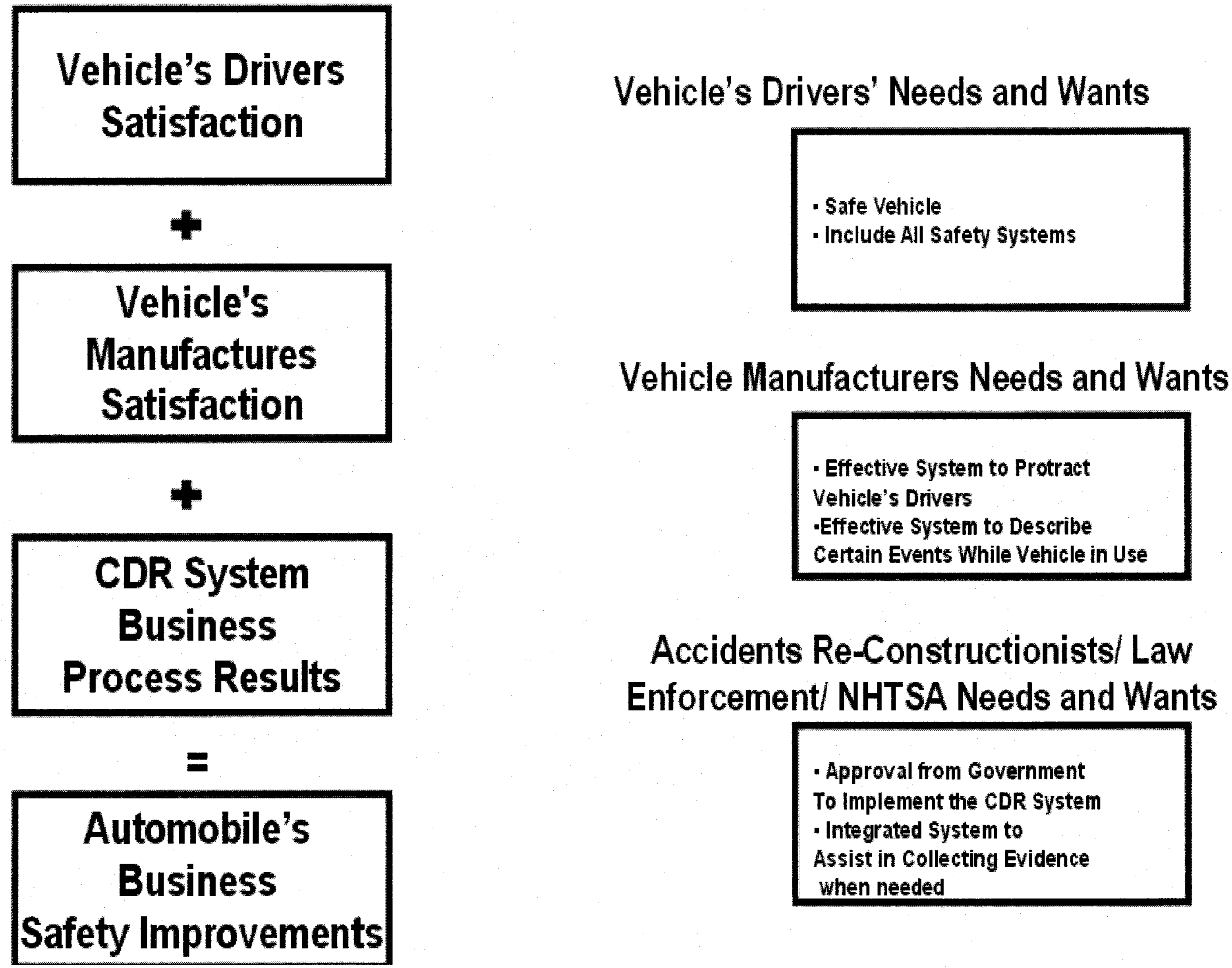


Figure 4.18: Automobile's Business Needs and Wants

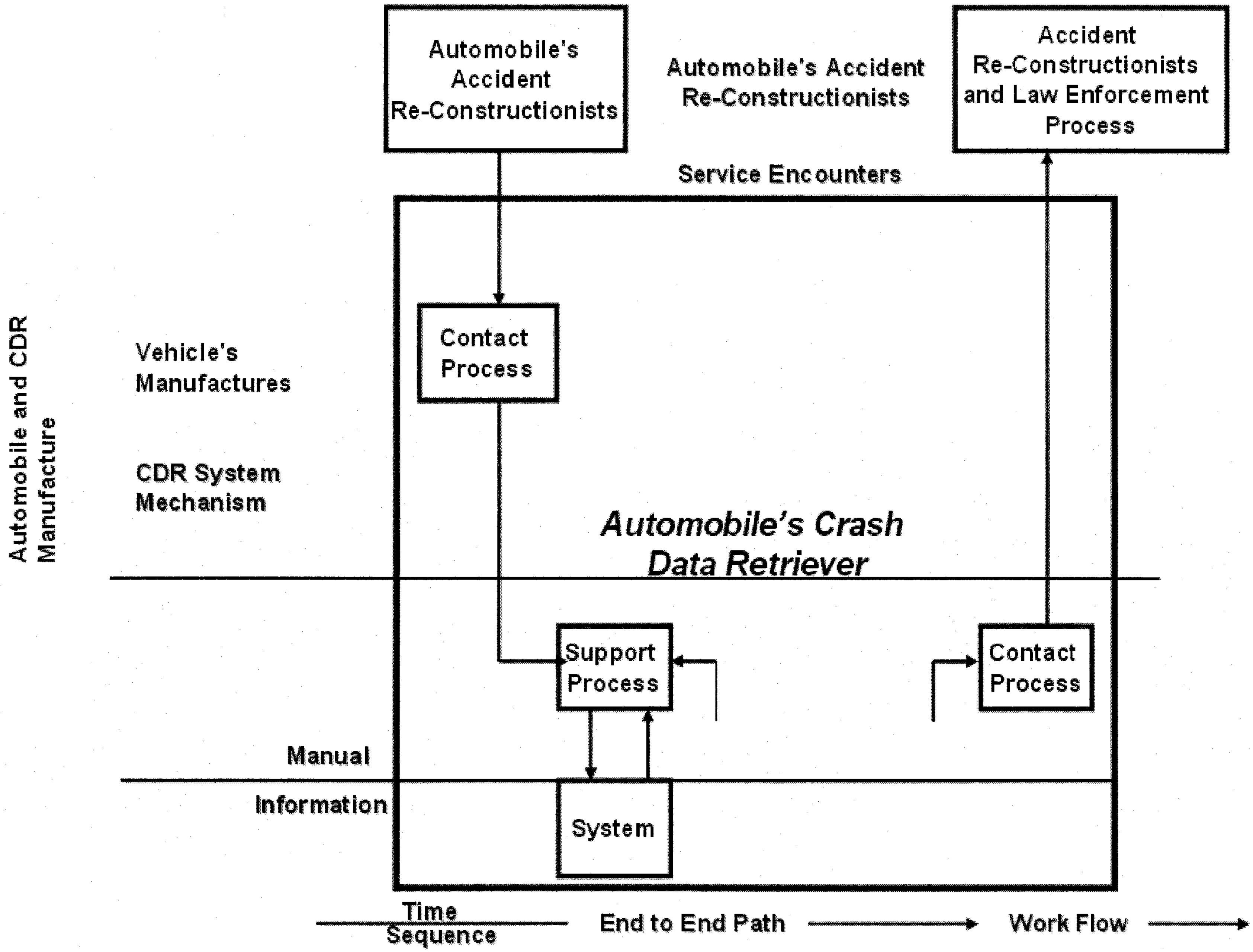


Figure 4.19: Crash Data Retrieval Line Of Visibility Chart

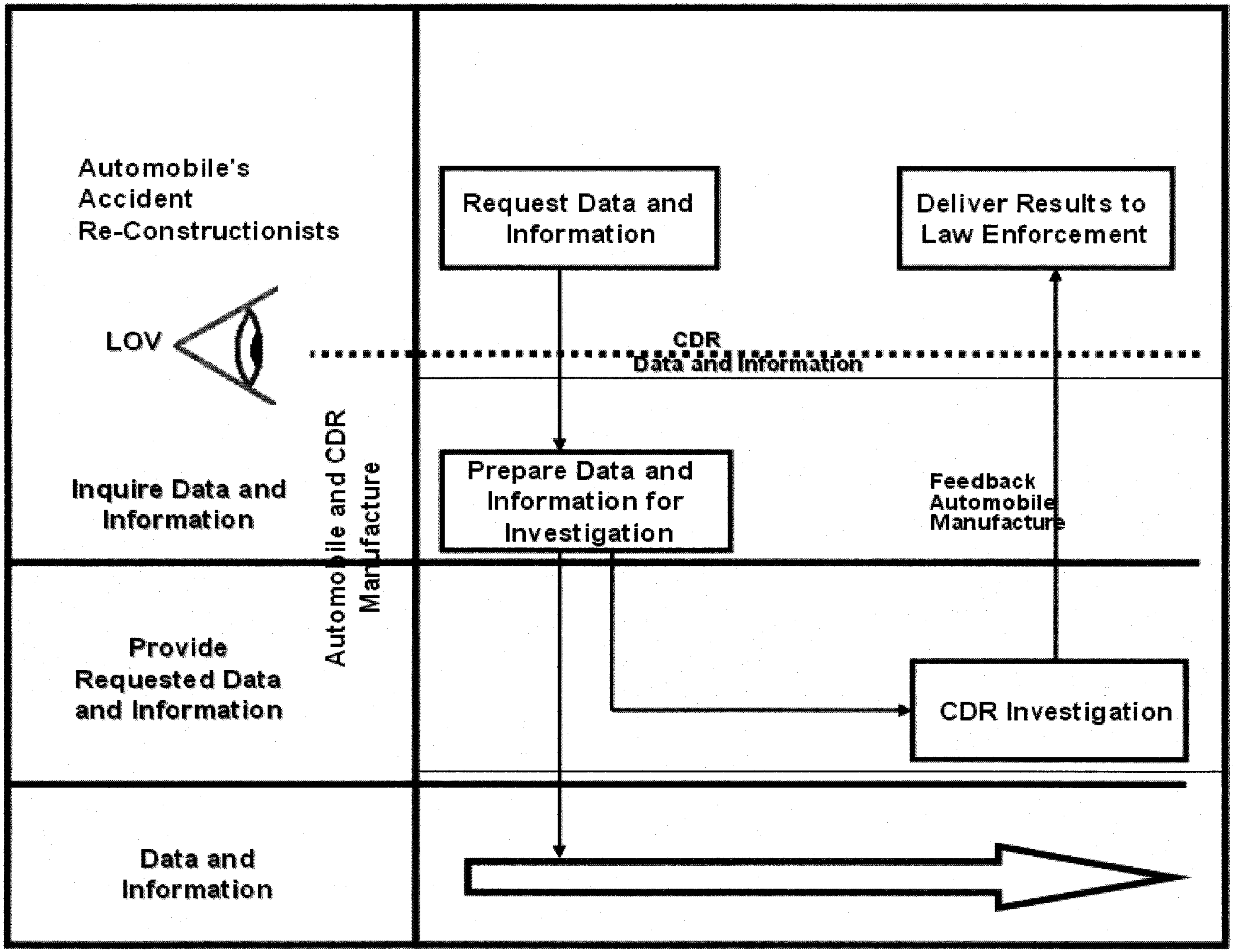


Figure 4.20: Selected LLOV Chart For Modeling the Crash Data Retrieval System Line Of Visibility Chart

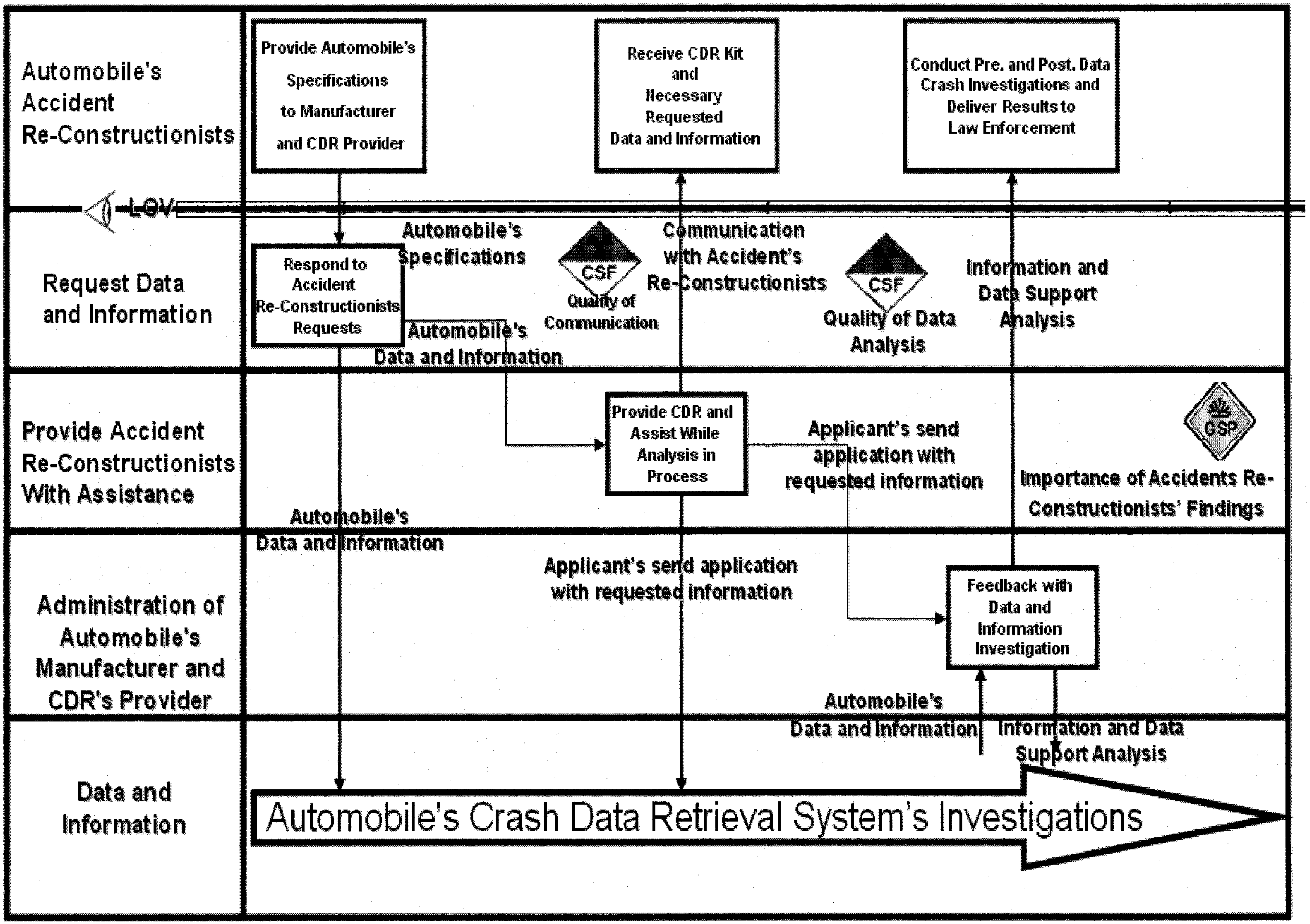


Figure 4.21: Selected LLOV Chart For Modeling the Crash Data Retrieval System for Automobile's Accidents Investigation

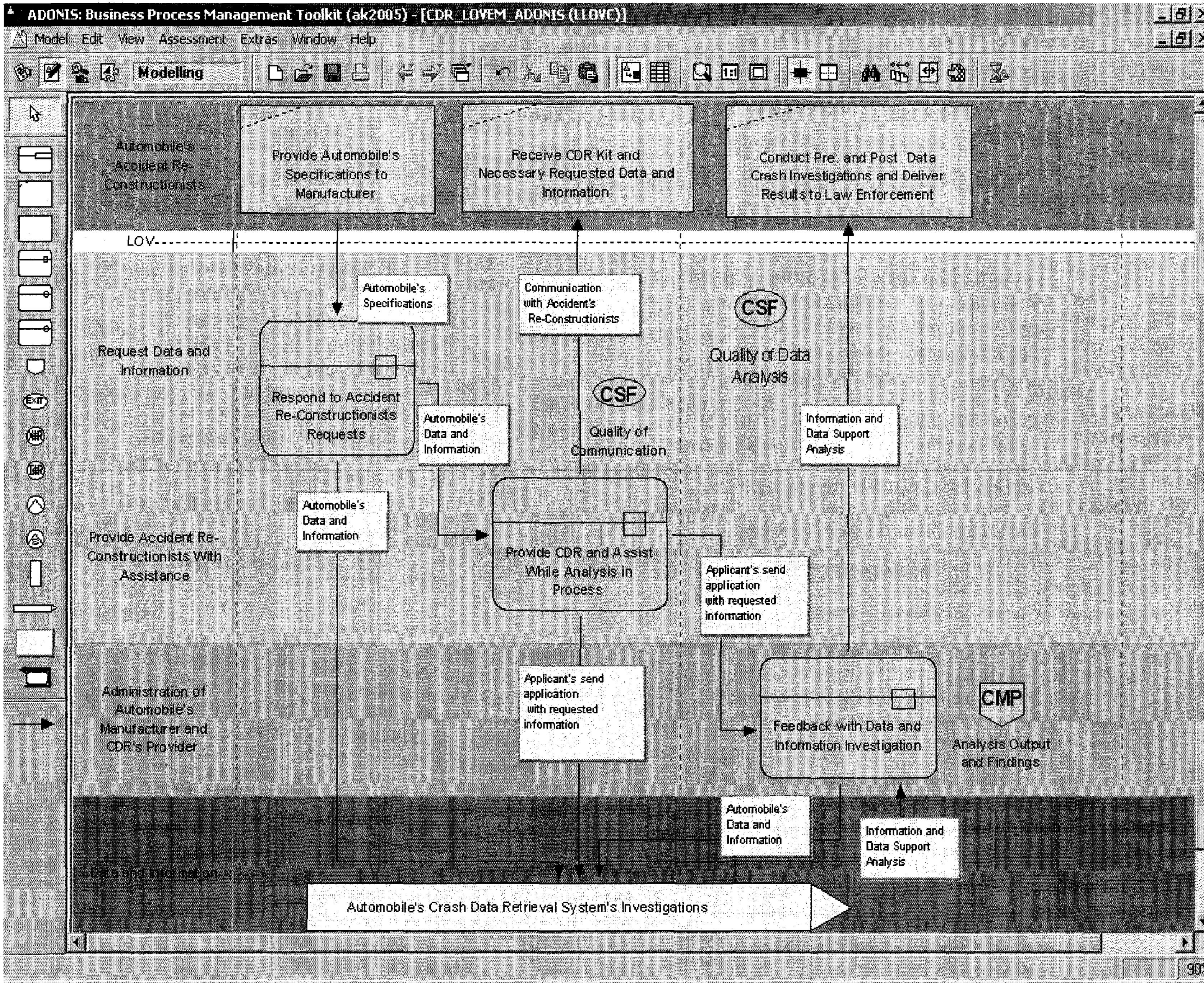


Figure 4.22 The ADONIS – Line Of Visibility Chart Of The Automobile's Crash Data Retrieval System

4.5 Architecture Of The Integrated Information System Representation

4.5.1 Power Point Representation

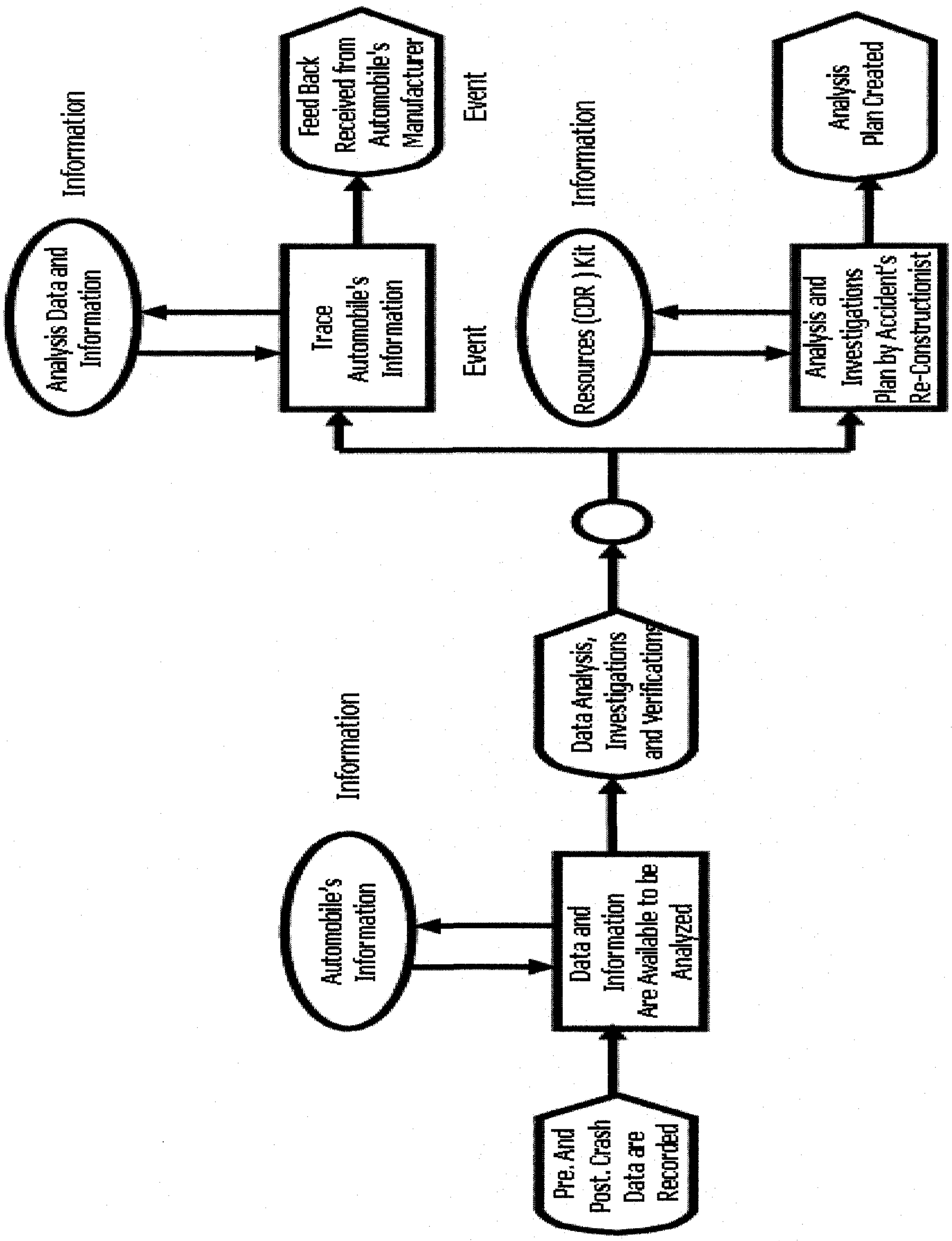


Figure 4.23: ARIS Representation Of The Crash Data Retrieval System Data Processing

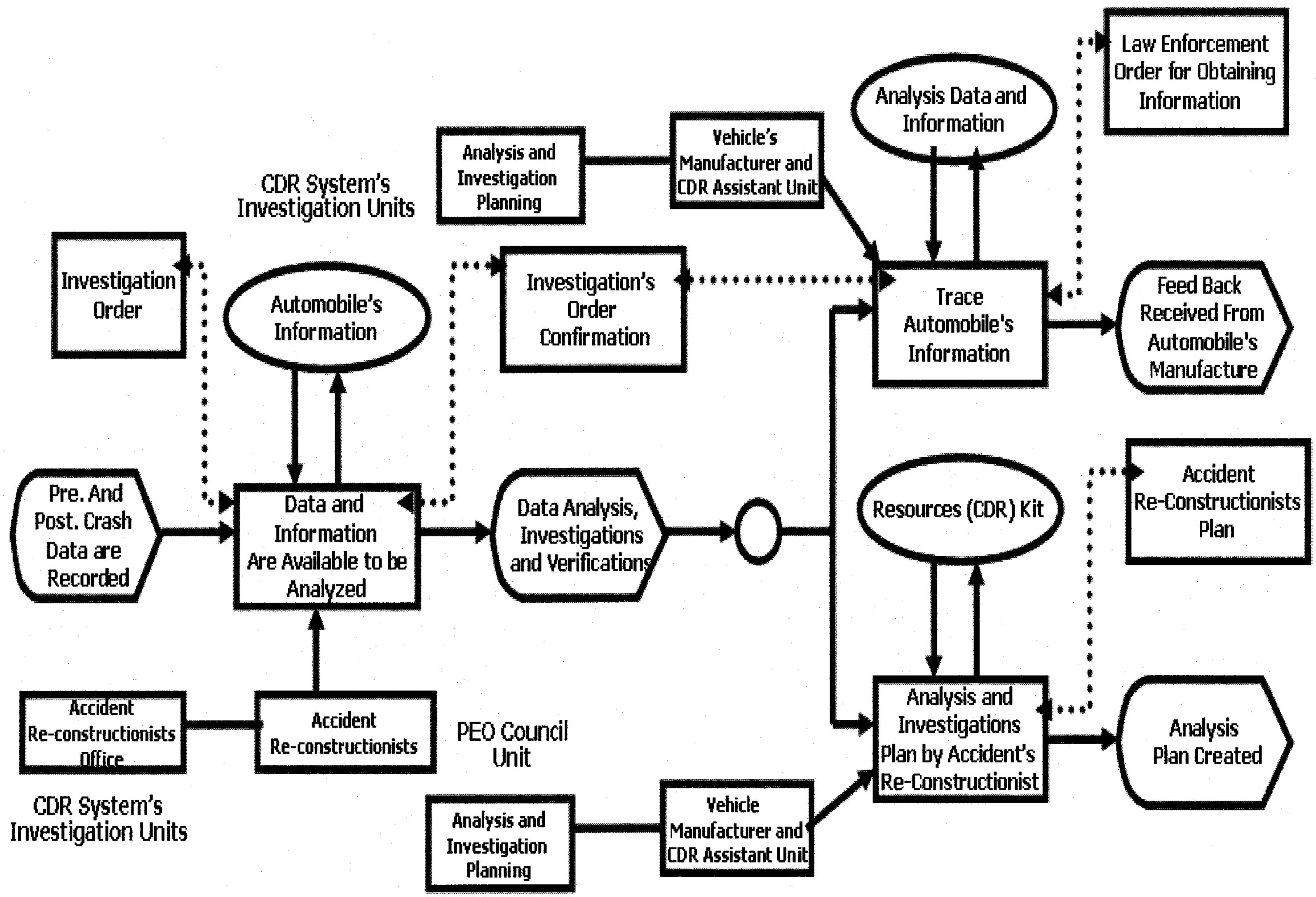


Figure 4.24: ARIS Representation Of The Crash Data Retrieval System's Function Processing

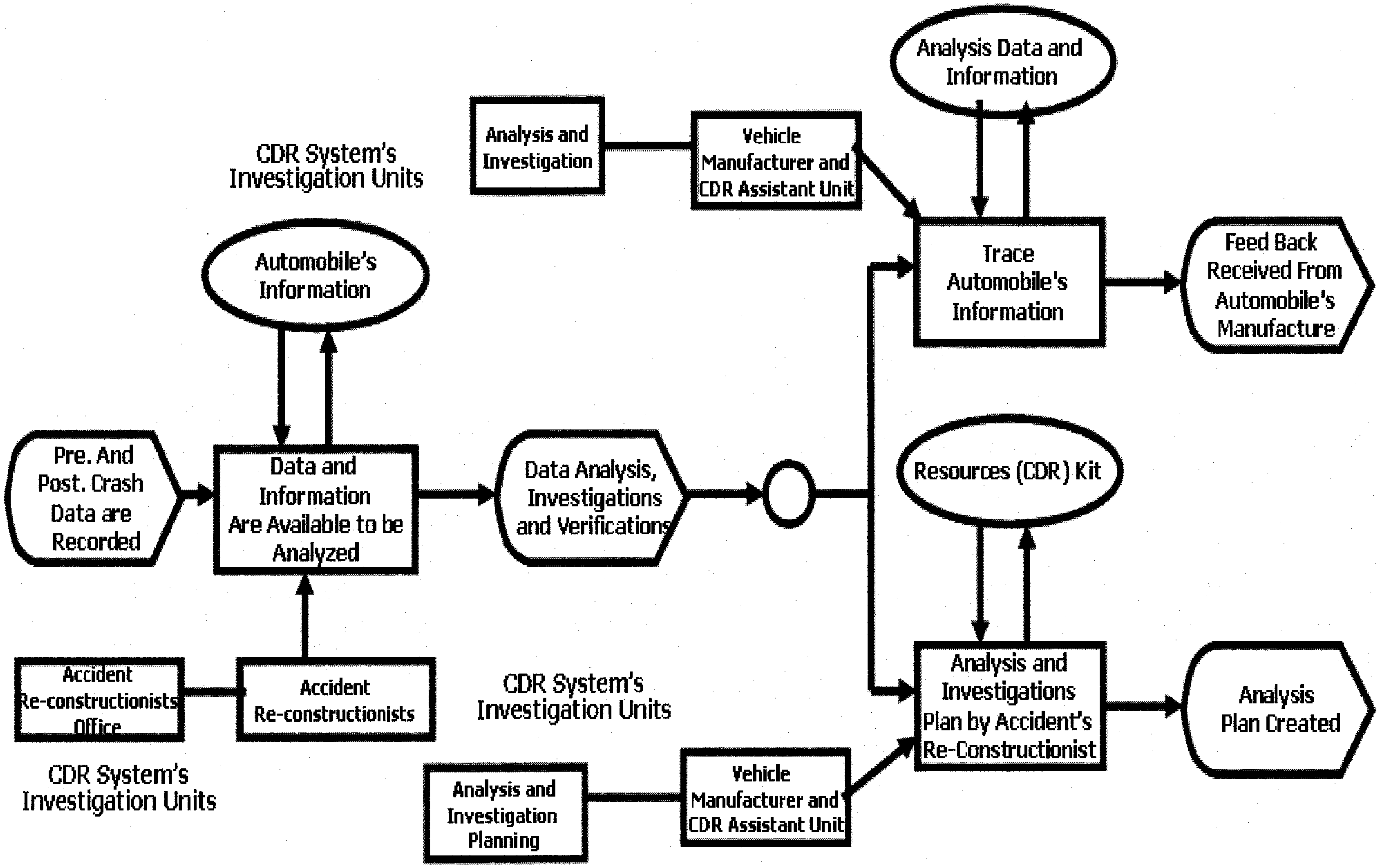


Figure 4.25 :ARIS Representation Of Functions Processing By Resources Belong To Crash Data Retrieval System's Investigation

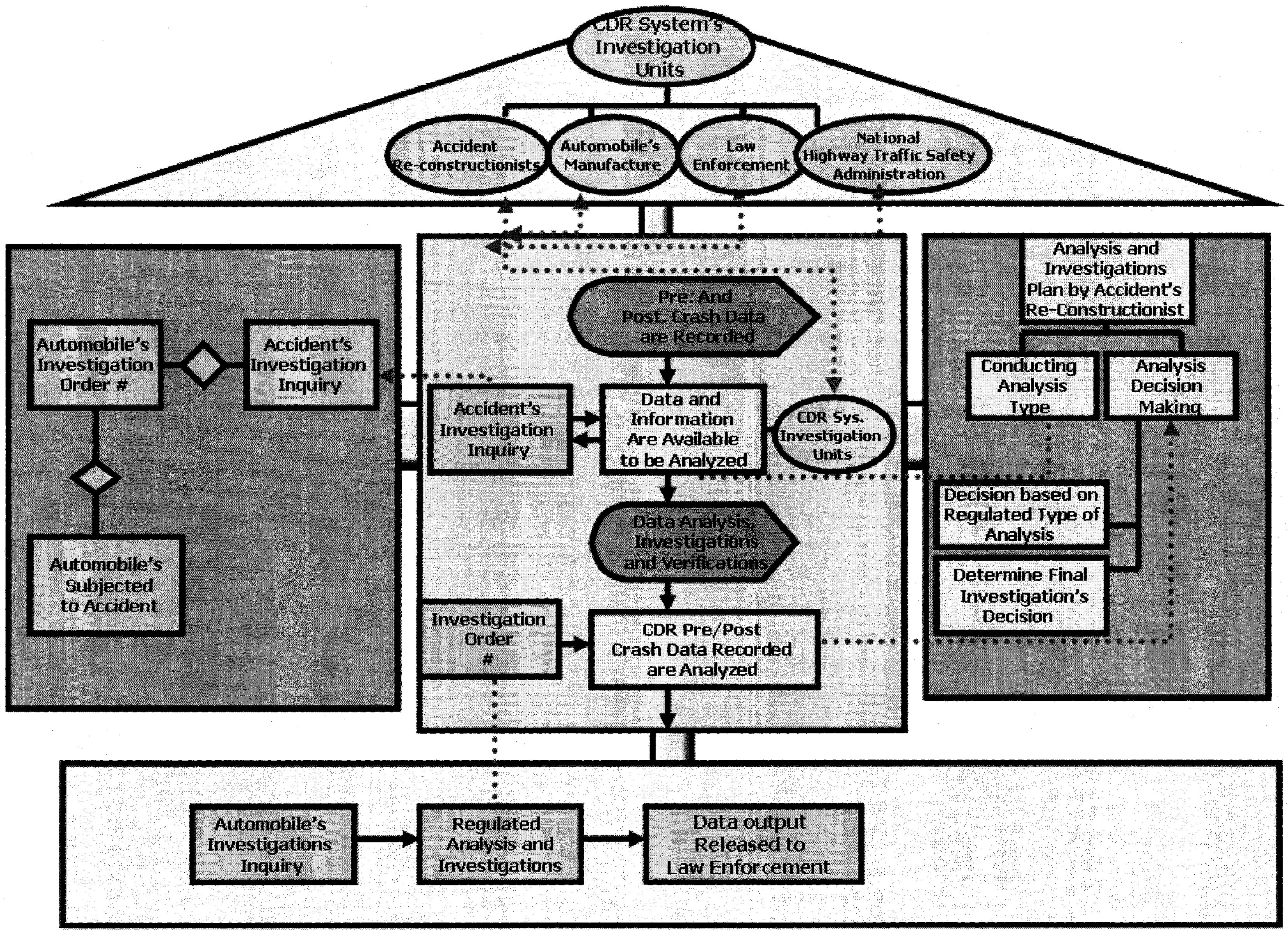


**Figure 4.26 :General ARIS Framework
Representation Of The Crash Data Retrieval System**

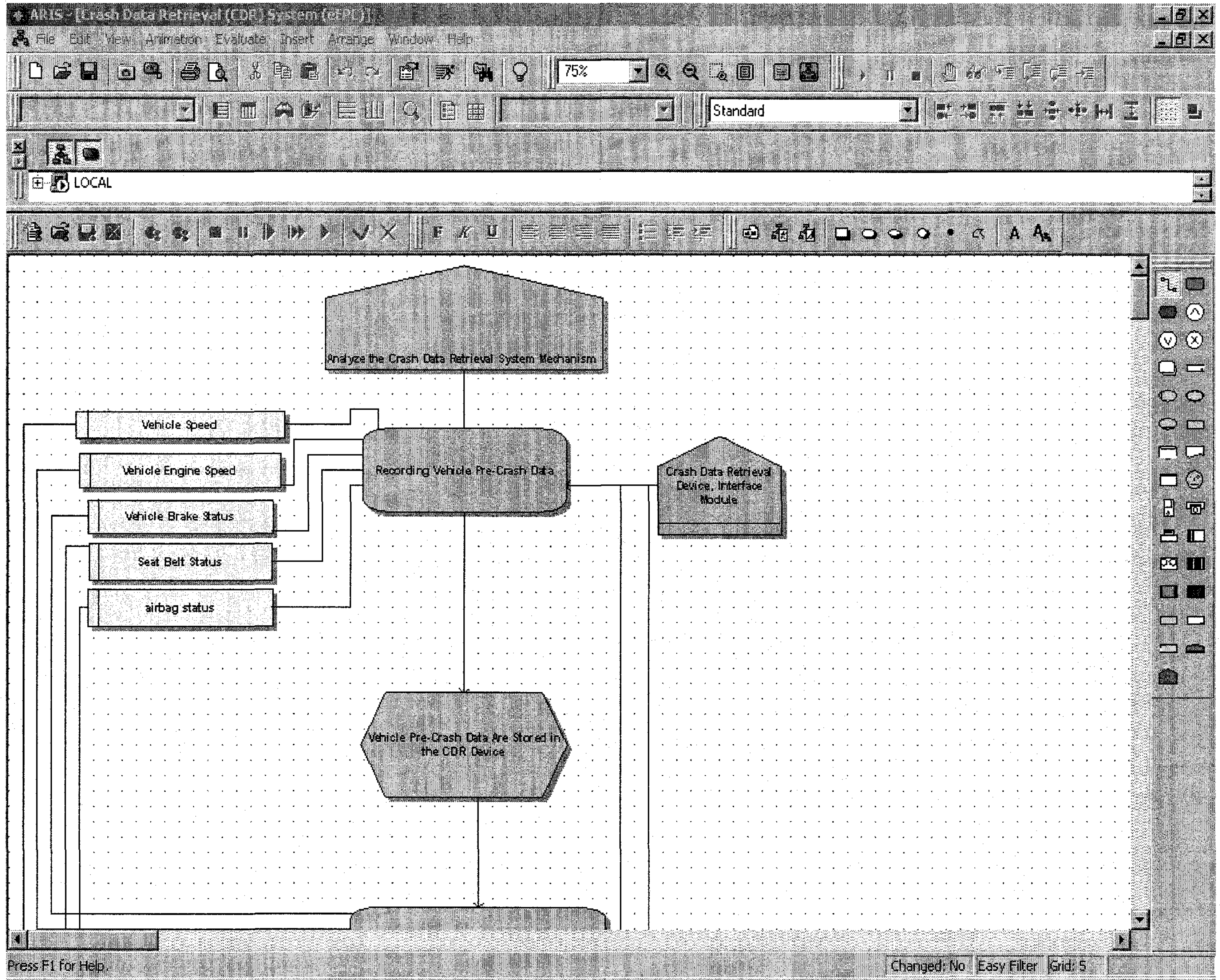


Figure 4.27: ARIS Tool Set Representation Of The Crash Data Retrieval System

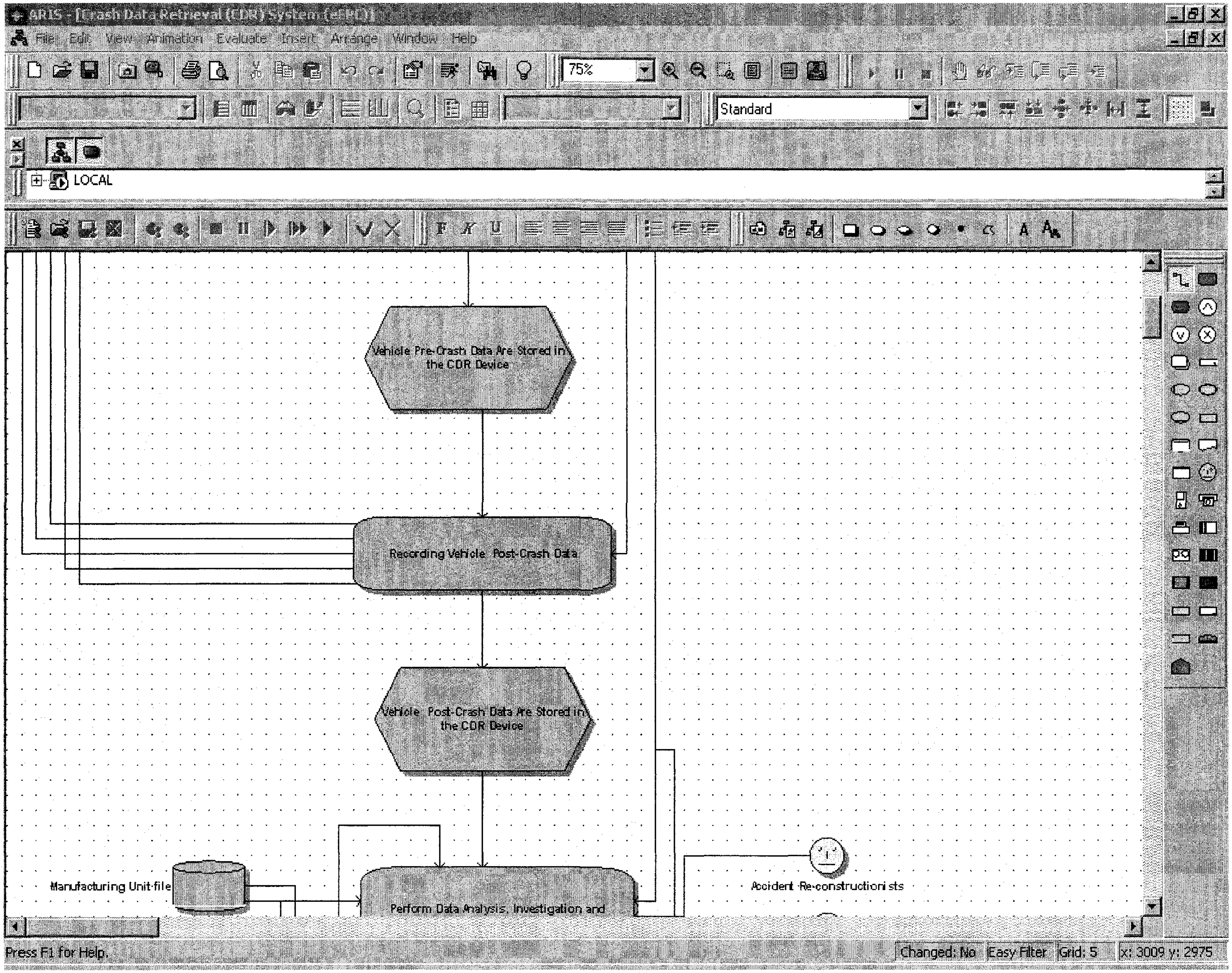


Figure 4.28: Continue ARIS Tool Set Representation Of The Crash Data Retrieval System

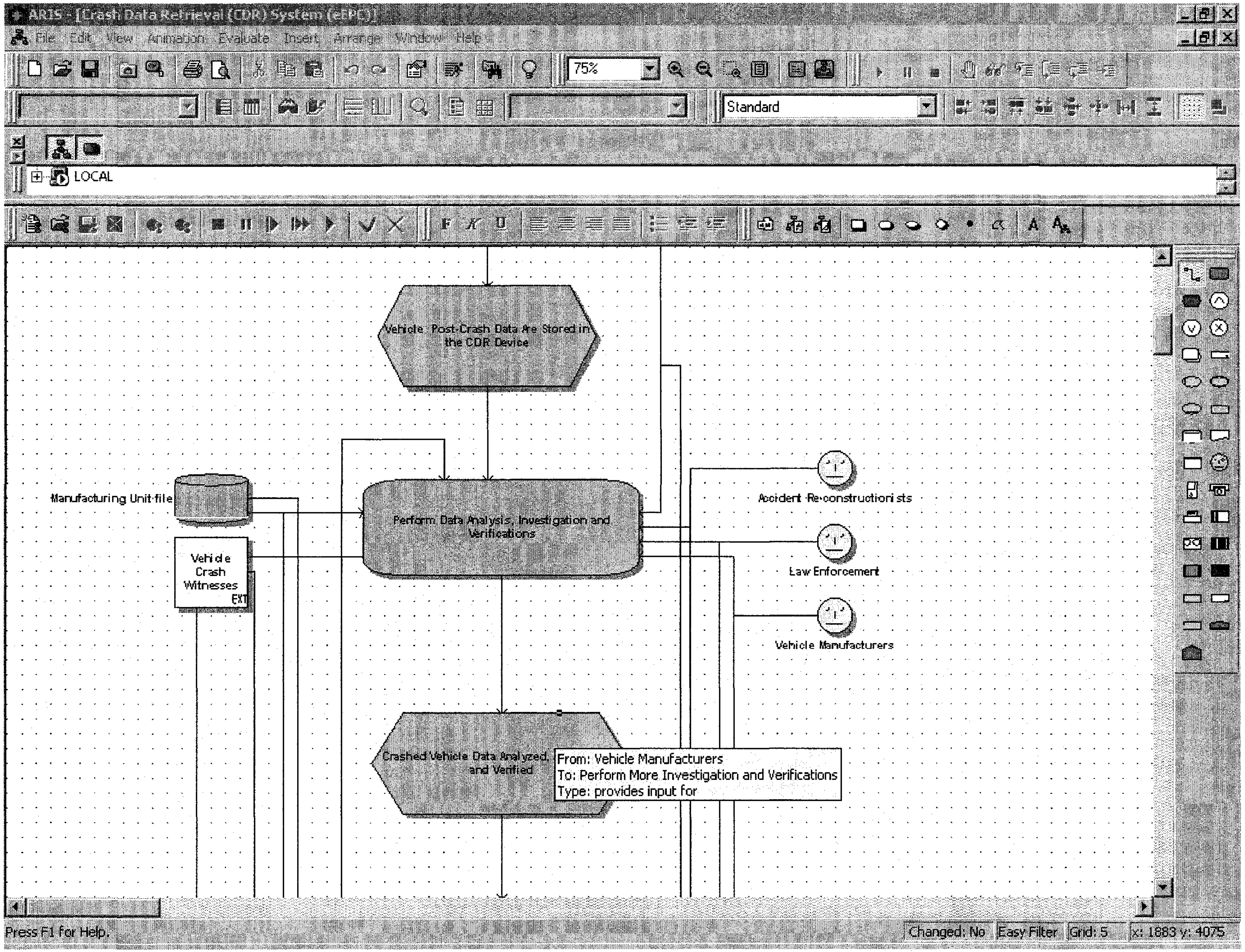


Figure 4.29: Continue ARIS Tool Set Representation Of The Crash Data Retrieval System

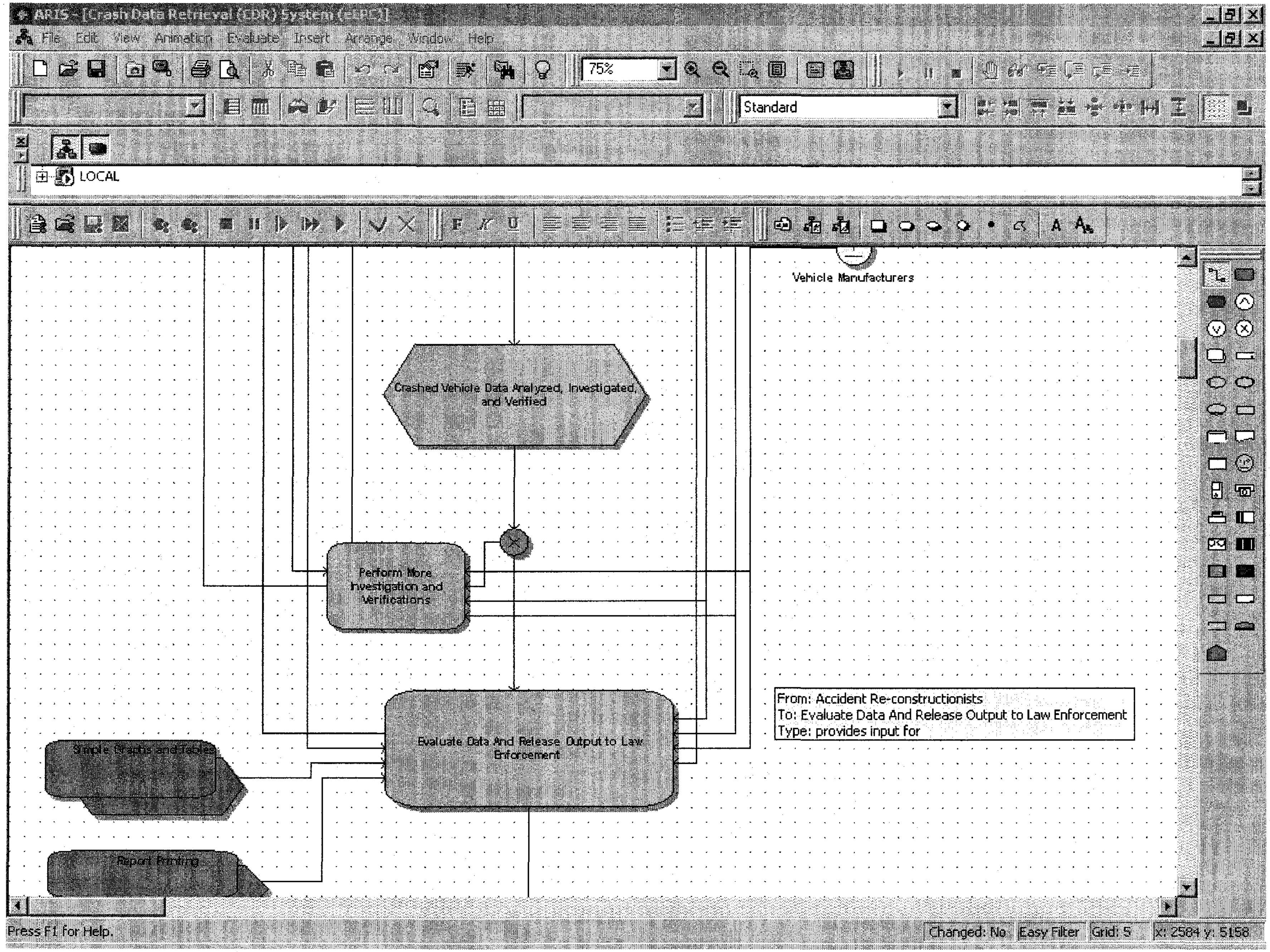


Figure 4.30: Continue ARIS Tool Set Representation Of The Crash Data Retrieval System

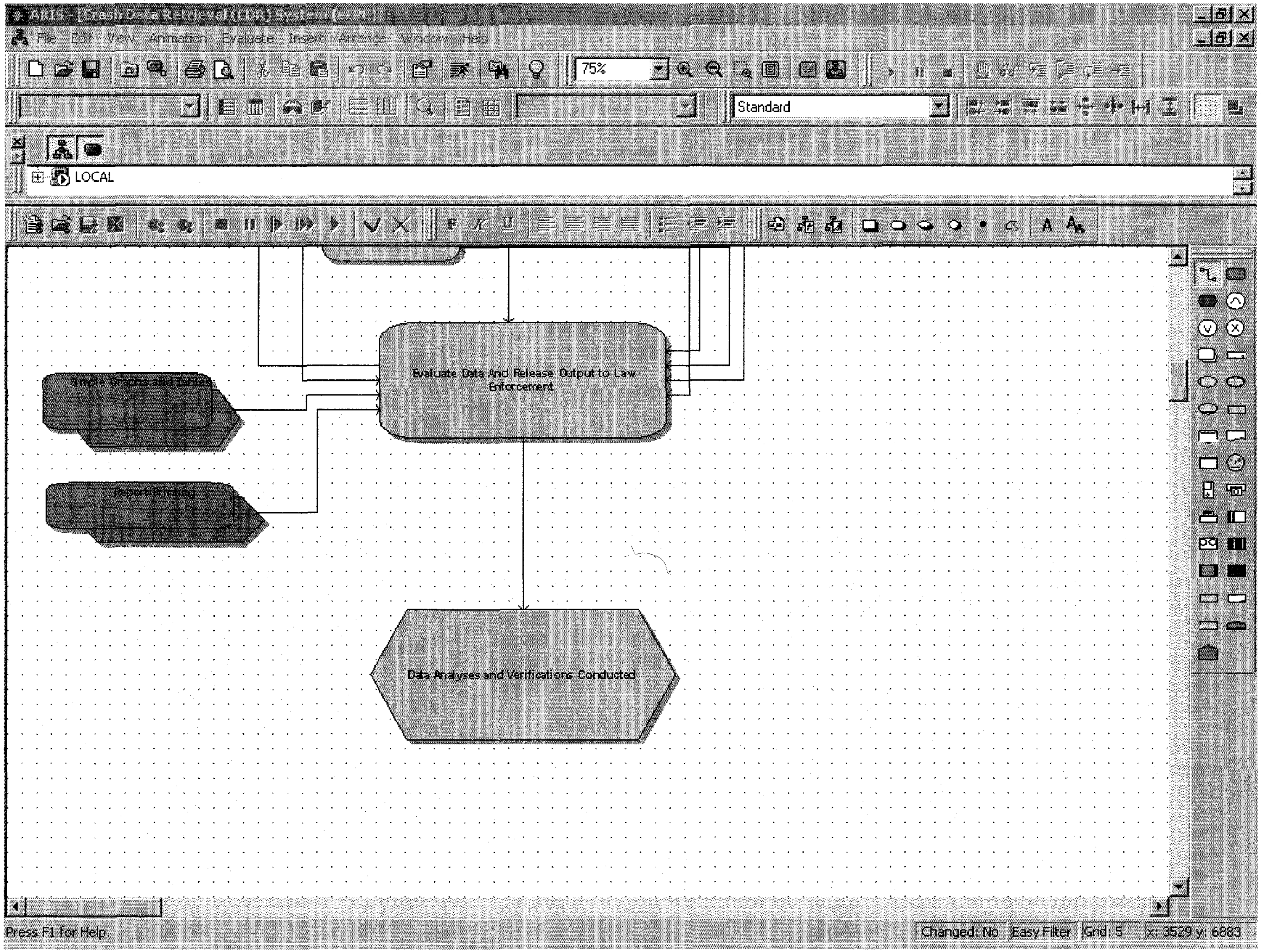


Figure 4.31: Continue ARIS Tool Set Representation Of The Crash Data Retrieval System

4.6 Discussions Of Output of Modelling Methodologies

The CDRS design contents as well as variety of its components and relationships between them have been graphically represented, through the selected processes modelling methodologies by using their associated tools. Modelling the CDRS has resulted in examining its information complexity, variety, uncertainty, accuracy, and usefulness. As mentioned earlier, the CDRS is an innovative hardware and software product that allows downloading vehicle-specific accident data from General Motors vehicles involved in an air bag-deployment or near-deployment collision [Vetronix Inc., URL : http://www.vetronix.com/ppt/brochures/CDR_Overview.ppt].

The $IDEF_0$ design methodology has assisted in facilitating the process understanding, analysis, and improvement of the CDRS process. Because the CDRS processes are composed of interfacing or interdependent parts that work together to interpret relevant information, its $IDEF_0$ representation by using the AI0WIN7 has enabled modelling its process parts. That includes combination of users, information, software, and equipment required. In addition, the use of this tool set through its CDR-$IDEF_0$ model has described what a CDRS process does, what controls it, what things it works on, what means it uses to perform its functions, and what it produces.

The output of using the $IDEF_0$-AI0WIN7 for modelling the function and activities of the CDRS, has assisted in gaining understanding, supported analysis, and provided logic for potential changes. Since the CDRS collects the information stored on the air bag sensing and diagnostic module, using the $IDEF_0$-AI0WIN7 has resulted in specifying the requirements before synthesising all the CDRS key elements for decision-making by the accident re-constructionists. This has supported the CDRS level design and integration activities.

The CDR-$IDEF_0$ process map is composed of a hierarchical series of diagrams that gradually display increasing levels of abstraction, describing the system's functions and their interfaces in the context of the process. Such representation has included the vehicle speed, engine speed, throttle and break data in one-second increments for the five seconds preceding the crash.

Representing this type of information by using the $IDEF_0$ - AI0WIN7 tool set, will be useful when accident's deconstructionists together with crashed automobile manufacturers, and law force synthesis all the decomposed activities required to be performed while supportive legal decision-making is made. However, the CDRS is a simple way to access the information stored on the vehicle's air bag module. Interpreting the events stored on this device is considered to be complex. This is because of the nature of its data and information's environment. Because of that, modelling the system's process by using the $IDEF_0$-AI0WIN7 tool set is very desirable to identify errors and problems in an early state of the system modelling.

The CDRS allows the investigator to input other pertinent information, such as weather conditions, and export the data to a remote database. The graphical output of this complex process has resulted in a model composed of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. The hierarchical structure of the CDR-$IDEF_0$ model has resulted in quick mapping at a high level. The CDRS processes sequencing has been illustrated in the $IDEF_0$-AI0WIN7 model. That successfully identified opportunities for improvements while revealing data and information relationships from the CDRS device.

As a tool's capability described earlier in the first case study, the generated CDR-AI0WIN7 model has included an entire report that is generated automatically by the tool. Such report is considered to be a good asset while communication and transformation of information between accidents' re-constructionists and law force. This is because of the format of the generated report that includes associated input, output, mechanism, and control. Such contents are associated with any event the CDRS has recorded where that needs to be available while legal decision-making is delivered to the court and insurance company.

The generated report from the CDR - AI0WIN7 compliant methodology has the advantage to include any content to be considered as a detailed legal reference(s) associated with the events representing the pre/post crash data. Analyzing the interactions between the CDRS internal components and users and beneficiaries has resulted from using the LOVEM-BPM modelling methodology through its compliant tool kit ADONIS.

The CDR-LOVEM has been implemented in this case study to assist in reducing its process complexity. That has been by explicitly presented by involving the system's users particularly the accident's re-constructionists while they are monitoring the sequence of the process (Upper Eye). The capability of the LOVEM subject oriented methodology where process sequencing is embedded in its model has supported the assumption of its ability to identify errors and problems in an early state of the system modelling.

Adding to the fact that the LOVEM has successfully assisted in graphically representing the CDRS process and sequence of its events, its main subjective output can potentially improve in so many ways the CDRS. Determining the process redundancies is the major one. At the stage of reengineering the interactions of the systems elements, system's developers can determine criteria to simplify the process. This is because there is a need of improving its subjective performance. Using the ADONIS tool kit has assisted in defining and documenting in context all CDRS processes and events, including its CMP, CSF, and also GSP.

The CDR-ARIS framework has distinguished between four different levels of abstraction in the CDRS. It assisted in specifying the automobile's driver's requirements and for modelling the business processes of the CDRS applications. In addition, the case study has illustrated each of these views in this subject-oriented model, and described in different levels of abstraction. This is for optimizing the CDRS processes functionality and achieves its manufacturer's strategic goals.

Although process sequencing is not well embedded as in $IDEF_0$ and LOVEM, its modelling capability can be explained through its effectiveness in realizing all aspects associated with the CDRS processes mechanism. This has subjectively resulted in an information model that is the keystone for a systematic and intelligent method of developing application systems focusing on improving the CDRS performance for providing more justifiable legal output to the court and the insurance company.

The ARIS report has been automatically generated as a result of the CDR-ARIS model as illustrated in Appendix B. However, the CDR-ARIS neither provided means to validate the resulted model nor sequence of the information was embedded, it can be considered as a very good approach to identify errors and problems in an early state of the system modelling. This is because of its subjective effectiveness of detecting any complexity associated with storing necessary pre/ post automobile's data where precise interpretation of such data are mandatory or decision-making is considered unsatisfactory.

The underlying fact is that the CDRS processes are subject to other factors beyond data and information stored on the CDR device. That will include claimed to be an accident witness, conflict of expert's opinion, as well as important keys required for synthesising all facts. Using the ARIS tool set has assisted in developing and analyzing the CDRS process model through an ARIS report automatically generated in different format (e.g., html, M.S. word) as illustrated in Appendix B.

CHAPTER 5

DISCUSSIONS, CONCLUSIONS, AND FURTHER RESEARCH

5.1 Discussions

5.1.1 Business Processes Modelling Case Study

The process modelling applications have become increasingly important. The main reason for this increased interest is the need to provide computer aided system integration of the enterprise based on its business processes. This need requires a technology that enables integrating modelling simulation and performance of processes into one single tool. If the process model is considered a correct representation of the process logic, a modelling tool can help verifying whether or not the process, as designed and implemented, will meet its targets? Once the process model is implemented, various execution measurements can be monitored. The process performance monitor will collect and represent the actual behaviour of the processes.

As mentioned earlier, there is a desire for capturing the business process requirements because the business processes have become more complex. That will be achieved by getting more visibility into the process management, by detecting problems and areas for improvements. Selecting the right comprehensive methodologies and tools is believed to be one of the most effective key issues that need to be considered for mastering the complexity in processes modelling.

The implementation part of this thesis has selected three main processes modelling methodologies ($IDEF_0$, LOVEM, and ARIS) represented through their associated tool kits (AI0WIN7, ADONIS and LOVEM in ADONIS, and ARIS). Such implementation has been demonstrated through the two case studies. In addition, the output models have been demonstrated in both case studies.

As a main objective of the implementation part in both cases studies of this thesis, the focus should be dedicated on comprehensive modelling methodologies for the development, management, and improvement of the enterprise business processes. This is because of the operational complexities, which are considered as a major barrier to a good processes management and enterprise improvement. Previously, most work done by researchers has covered only one type design methodology for modelling the functional relationships and data or information flow. This is a major motivation, which triggered the need for further research, as the traditional design methodologies have focused on the simple processes flow charting types problems, which are believed to be insufficient for representing and including the enterprise processes, particularly when their functions and activities are too complex to be represented.

Although converting the business process flow charts to a comprehensive graphical representation with integrated set of graphical modelling methodologies is considered to be a main desirable contribution in this thesis, further investigations for justifications of the usefulness and effectiveness of such objective has been addressed as well. The three selected design methodologies implemented by using their tool sets have assisted with initiating further research investigation for determining which one(s) can successfully capture, analyze and redesign the enterprise processes. Because of that, there is a need to provide comparisons analysis of the selected processes modelling methodologies and tools, including their capabilities and deficiencies.

This is considered as a mandatory requirement to understand which methodology is suitable for certain processes modelling problem based on its complex environment's nature. Such objective will be based on measuring the improvement in the business processes performance achieved from the two business models resulted from the two case studies presented in this thesis.

The literature has presented an overview of the processes modelling methodologies particularly ($IDEF_0$, LOVEM, and ARIS) represented through their associated tool kits (AI0WIN7, ADONIS, and ARIS).

Briefly, the $IDEF_0$ approach has contributed, through the use of the AI0WIN7, in providing detailed description for the business processes inputs, outputs, mechanisms, and controls. From a different perspective, the monitoring eye in the LOVEM has subjectively attempted to analyse, and model the interactions between customers and the internal processes through the LOVEM in ADONIS tool kit. The ARIS different views which have integrated the use of the Zachman framework, has attempted to recognize the organization view, data view, function view and also product/ service view by using the ARIS tool set.

As stated earlier, the purpose of the business modelling is to identifying areas of improvement, and better understanding of the business. To determine which developed model in both Cases Studies is considered as a (Business Process Improvement) or (Business Process Reengineering) intended model, it is necessary to emphasise on their main objectives. The BPI approach is considered to be incremental change based on the business model where changes are applied in small continuous steps. This is for minimizing any possible negative impact on the business. Both business processes as well as model are considerably changed when implementing BPI and BPR approaches. Substantial improvement might be achieved but also implies a higher risk of failure If not successfully considering all aspects of the existing business. Comparing to BPI, the BPR implies a high risk and also a task difficulty and may encounter strong resistance from human resources and even fail because of the mentioned reason [Fitzgerald, 2002].

Where both approaches can be compared based on the pace, depth of change and the implications of such concepts, BPI is based on documenting the "AS-IS" process, establishing measures and then following the business process. The business performance is then measured where improvement needs to be identified then implemented. As illustrated earlier, the BPR is based on redesigning the business processes to achieve dramatic improvements in critical, contemporary measures of performance.

In this section as well as in section 5.1.2, the output of the two case studies implemented in this thesis will be analysed for the purpose of determining if BI has been achieved or not. This will be determined on the basis of the measuring criteria mastering the BPI/BPR approaches. To accomplish that successfully, both developed processes models need first to be determined of whether they are subjected to the BPI or the BPR according the process modelling case environment and measuring criteria for achieving desired BI.

Modelling the legislated business processes associated with the PEO's licensing procedure was based on documenting the "AS-IS" council's process. The business models developed by using the selected process modelling methodologies have certainly established some measures to be evaluated. Such measures will assist in measuring the business performance associated with the acts and regulations set by the Government of Ontario and its main representative (PEO Council) in the province of Ontario. The legislated BPI needs to be identified then implemented. Improving the performance of the legislated processes is dependent on successfully licensing the practice of professional engineers in Ontario, which will also provide its applicants a fair assessment and its legislators, a fair evaluation. This lies under the "satisfaction" measuring criteria. The process modelling work needs to address steps that the main three players are observing with the legislated processes. This is for determining where uncertainty exists to better improve the entire process performance with minimum allocated resources. On that basis, a selection-decision will be made, by determining the most suitable processes modelling technique(s) implemented for modelling the PEO's licensing process.

The $IDEF_0$ allows the structure of the PEO's legislated licensing processes to be represented in a hierarchically structured set of diagrams. The top-level diagram in the hierarchy represents the PEO's licensing processes procedure as a set of interacting activities. Second level diagrams represent each of these (top level) activities as a set of interacting (lower level) activities, and so on down through as many levels as were necessary.

Implementing the $IDEF_0$ design methodology has assisted in modelling the legislated PEO's licensing processes procedure. It is very important to mention here that the use of the $IDEF_0$ processes modelling technique in the first case study has been intended to model the licensing processes within the PEO not how they are legislated. The activity decomposition based technique has successfully assisted in achieving a very rich set of process understanding.

For instance, a detailed decomposed activity associated with relating a Non-(CEAB) accredited program has determined all applicable situations that might be resulted from such a case. Adding to this methodology's capability, the AI0WIN7 has facilitated such legislation verification through the possibility of linking any activity with its associated legislation released by the Government of Ontario [PEO Council, URL: http://www.peo.on.ca/; R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)].

As mentioned earlier, the requirements of the PEO's perspective applicants, which they need to satisfy, are based on analyzing the specific academic background. It was stated that if a bachelor's degree in engineering has been obtained from a non-CEAB accredited program, applicants' qualifications would be assessed against (CEQB) criteria in the specified engineering discipline.

In addition to the capability measuring criteria of the $IDEF_0$ – AI0WIN7 model, it has been demonstrated that sequencing was embedded in the model. It has successfully assisted to determine opportunities for improvements and revealing information relationships. This is mainly by producing a structured representation of the PEO's functions, and activities within the modeled system.

The PEO-$IDEF_0$ developed model was capable of graphically representing a wide variety of the PEO's legislated licensing procedure to any level of detail. This is considered as a mandatory requirement to understand and improve the licensing processes. The automatically generated reports that summarize the developed model in this case study has assisted in two main aspects. First, it is an approach to understand the legislated licensing processes, particularly when looking at the entire modeled activities by viewing the model tree diagram. This is considered as an approach to review the "AS-IS" processes, and then detecting if current inputs, outputs, control and mechanisms might need to be modified. If so, resources allocated for such activity can easily be determined while working on the (BPI) with the might to be a priority one. For instance, the current PEO-IDEF$_0$ model has demonstrated the mandatory requirements to enable perspective applicants need to fulfil to enable them write the (PPE) test. If any modifications will come from the Ontario's government to re-regulate such activity, it will be easily possible to determine how much resources are required to do so [R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)].

The main capability of IDEF$_0$ is that the method has proven its effectiveness in detailing the system activities for function modelling. However, one of the observed concerns with IDEF$_0$ developed models is that they are so concise where rectangles and lines are given same weight; in a rigid hierarchical structuring. In addition, that would still raise a question of why not enhancing abstractions provided by lines, not only for enhancing abstractions provided by rectangles. This leads the developed model to be understandable only if the reader is a domain expert or has participated in the model development. This can be justified if the lines represent a complex interaction [Pratten, 1997].

The hierarchical nature of the IDEF$_0$ has facilitated the ability to construct the "AS-IS" models that have a top-down representation and interpretation based on a bottom-up analysis process. The tendency of PEO-IDEF$_0$ model can be interpreted as representing a sequence of legislated activities. However, the literature has stated that IDEF$_0$ is not intended to be used for modelling activity sequences. That will bring us the possibility to assume that in cases where activity sequences are not included in the model, readers of the model may be tempted to add such an interpretation.

However, the input of the PEO's perspective applicants has been included implicitly in the developed PEO-IDEF$_0$ and PEO-ARIS models; the main idea of the LOVEM was to subjectively include it explicitly. The criteria of the measuring performance capability that the LOVEM needs to be evaluated with, can be explained through the effectiveness of involving the applicant's monitoring eye in the PEO's BPI. This can be viewed from different angle by assisting the PEO with reallocating available resources by eliminating redundant activities and improving the performance of the bottleneck ones.

It is vital to mention in this part that neither IDEF$_0$, nor LOVEM and ARIS have embedded any objective of satisfying any business stockholders by violating other's interest. The point to be made here is as follows, reaching customers' satisfaction objective that has been implicitly embedded in IDEF$_0$, and ARIS but explicitly in LOVEM, has been based on a clear objective. Such legislations need to be fair and clear to the three main players. They are the Government of Ontario as a main legislator, the PEO council as the Government of Ontario's main representative to communicate with third party including applicants who have interest to practice the engineering profession in Ontario.

Detecting where delays might result in the PEO's legislated process has been assisted to determine where assigned resources for certain redundancies can be shifted to complex activities for improving its performance. This has been achieved after defining and documenting in context PEO's business rules and policies including its CMP, CSF, as well as its GSP.

The LOVEM methodology didn't focus on how many eyes to be included as much as including the highest weighted eye that its customers needs to be considered. This is why its main definition was stated as a graphical design approach for the business process and workflow design or redesign using an integrated set of graphical modelling methodologies that helps in analysing and redesigning interactions between business, customers and internal processes [IBM Global Services, 2000; Trautmann, 2000].

In addition, the focus on involving the third eye (Government of Ontario) was neither explicitly nor implicitly embedded in this methodology. This can be considered as one of the LOVEM deficiencies. In other words, observers of the output modelling work can assume that the PEO's council is the licensing processes legislators. To integrate the use of this methodology, there is a need to include a third eye that will integrate the PEO's regulated processes by assigning it to the Government of Ontario. The extended work of the PEO-LOVEM has been presented in Appendix E. This has been included in this thesis to demonstrate the favourable achievement of the system's developer monitor in integrating the LOVEM approach for the BPI.

In addition to the fact that the capabilities of this implemented approach is to determine delays that might result while applications are under evaluation, achievement of such goal is dependent on certain information. That includes the LOVEM CMP, CSF, as well as its GSP. Such information need to be available with the PEO council to assist in detecting where procedures are affecting those who do not fulfil its requirements. Also, this will assist in determining how much resources need to be added to better improve the performance of the PEO's legislated processes.

For explicitly distinguishing between the PEO's council function, information and processes views, triggered the need of deploying the ARIS process modelling approach through the ARIS tool set. The PEO's licensing process procedure has been modeled in this case study. Its output has provided a well-documented framework that subjectively enabled the reader in understanding the entire PEO's licensing process during its life cycle phases.

The PEO's business processes are subject to change. The complexity of such legislated process can be viewed explicitly from the PEO-ARIS model. This is because of the main PEO's views required before issuing or revoking an application's application. In other words, the capability in this regard can be explained through ARIS effectiveness in realizing all aspects associated with the PEO's business processes. That doesn't necessarily lead to make this approach more favourable while comparing it with $IDEF_0$ and LOVEM in this case study. However, it has the benefit that it subjectively resulted in detecting and eliminating redundant activities and improving the performance of the bottleneck ones.

It should be noted that the hierarchical nature of the $IDEF_0$, and LOVEM can be interpreted as representing a sequence of the PEO's legislated activities, particularly for a non-domain experts, and the ARIS representation didn't assist in overcoming this concern.

It is believed though that all three implemented modelling tools AI0WIN7, ADONIS, and ARIS have implicitly overcome this concern. The generated report has the advantage to include any content to be considered as a detailed legislated reference(s). That includes the released to public documents assisted in understanding the PEO's acts and regulations associated with its licensing processes procedure [R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)].

Table 5.1 provides a summary of the detailed discussion of the implemented processes modelling methodologies including ($IDEF_0$, LOVEM, and ARIS) in the first case study is presented next. It focuses on addressing the processes modelling approach, capabilities and deficiencies detected after evaluating the modelling output resulted from using the modelling tool kits including (AI0WIN7, ADONIS and LOVEM in ADONIS, and ARIS).

Table 5.1: Summary Of The Output Approach, Capabilities, And Deficiencies Of The Implemented Processes Modelling Methodologies In The Business Processes Case Study

Technique	Objective	Approach Output	Capabilities	Deficiencies
PEO-$IDEF_0$ Model (AI0WIN7 Tool Set)	Object Oriented Approach for Modelling the PEO's Functional Relationships and Information Flow.	Easy Overview Representation and Control of Performance Shows the Inputs, Outputs, Control and Mechanisms Overview and Details of the PEO's legislated Licensing Processes.	Effective in Detailing the PEO's Functions/ Activities. Detecting Where Resources Might Need to be Reallocated by Realizing the delays in the Processes ABC Modelling is Enabled. Simulation Component Such as $IDEF_2$ Can Be Imported From KBSI's Library Management. High Capability of the Modelling Output Generated Report Using AI0WIN7 Tool Kit.	Rigid (When Compared to LOVEM/ARIS) Hierarchical Structuring that includes A lot of Notations. Domain Experts Might Be Required for technical Terms explanations. Doesn't Include any Animation Component in Order to Do Some Pre-Calculation of Possible Results in Reality. Doesn't Enhance Abstractions Provided by Lines. Only Focus on Rectangles' Abstraction. Non Domain Experts Might Interpret the Model as a Sequence of the

				PEO's Legislated Activities.
ADONIS BPM* Standard Tool Kit And PEO-LOVEM Model	Innovate Business Processes, Analyze and Design Organization, Workflows, and Staffing Requirements.	Explicitly Representing Needs and Wants of the PEO's Applicants, Employee, and Legislations To be evaluated. Improving the PEO's processes performance and Detect where Resources need to be Reallocated to minimize delays in application's evaluation.	Upper Eye' View (PEO's Perspective Applicants) Has Assisted in Determining Decision-Making Criteria for Improving PEO's Business Processes. Provided A Well Documented Methodological Framework to Enable Supporting the Entire PEO's Council Licensing Process During its all Life Cycle Phases. Includes Animation Component in Order to Do Some Pre-Calculation of Possible Results in Reality. Simulation Component (ARENA) Can be Imported	Not Enough Notations to Support Favourable Measuring Criteria Evaluation. Domain Experts Might Be Required for Technical Terms explanations. Non Domain Experts Might Interpret the Model As a Standardized Sequence of The PEO's Legislated Activities. Only Focuses on One Main Eye to Monitor the Processes. (the Government of Ontario's Monitoring Eye Needs to be Embedded to Achieve its Strategic Goals) Assist In

			From ADONIS Library Management Intermediate Level of Capability of the Modelling Output Generated Report Using ADONIS Tool Kit. ABC Modelling Enabled.	Selecting New Employees, Internal and External Interfaces
PEO-ARIS Model (ARIS Tool Set)	Representing the PEO's Business Processes and Improve the Council's Legislated Business Processes.	Distinguishing Between the PEO's Council Function, Information and Processes Views. A Well-Documented Methodological Framework to Enable Supporting the Entire PEO's Council Licensing Process During its all Life Cycle Phases. Achieve Optimized PEO's Legislated Processes Performance.	Provided A Well Documented Methodological Framework to Enable Supporting the Entire PEO's Council Licensing Process During its all Life Cycle Phases. Provided A Well Documented Methodological Framework to Enable Supporting the Entire PEO's Council Licensing Process During its all Life Cycle Phases.	Non Domain Experts Might Interpret the Model as a Standardized Sequence of The PEO's Legislated Activities. Domain Experts Might Be Required for Technical Terms explanations.

		Achieve Government of Ontario's Strategic Goal	Includes Animation Component in order to Do Some Pre-Calculation of Possible Results in Reality. Intermediate Level of Capability of the Modelling Output Generated Report Using ARIS Tool St Simulation Component (ARIS Simulation Module) Can be Imported From ARIS Library Management. ABC Modelling is Enabled.	

Table 5.1: Summary Of The Output Approach, Capabilities, And Deficiencies Of The Implemented Processes Modelling Methodologies In The Business Processes Case Study (Continue)

As described above, each one of the implemented design methodologies has its capabilities as well as deficiencies. The $IDEF_0$ has been determined to be concise and it appeared to assume its reader of being either a domain expert or participated in the developed model. Also, its many notations were capable in addressing all activities associated with the PEO's licensing processes procedure. Objectively, it can be concluded that the $IDEF_0$ was capable of presenting the measuring criteria of this legislated process to be evaluated with. On the other hand, its modelling output didn't explicitly detect where resources might need to be reallocated by realizing all possible factors that might cause in delaying of evaluating the PEO's perspective applicant's application.

The understanding fact is that this methodology has assisted in decomposing only the PEO's main licensing functions not the interfaces (e.g., mechanism). For instance, the possibility of having a contention for resources required to evaluate applicants for their experiential learning will be a major concern when number of non-CEAB applications increase. The PEO-IDEF$_0$ modelling output didn't capture the necessary information to successfully determining required resources the PEO council needs to invest during its applications' evaluation. For instance, the output modelling did not capture enough information for determining resources required to be allocated while transferring application for experiential learning by the (ERC). This is based on a direct request from the (ARC) to conduct such evaluation. The BPI associated with the PEO licensing evaluations' processes needs to address this concern while representing its AS-IS model.

In contrast to the PEO-LOVEM modelling output, The PEO-ARIS modelling output has assisted to explicitly capture and execute a very rich set of information during all its modelling fragments. Detailing the four main views of ARIS; has favourably assisted for better understanding the procedure of the PEO's legislated licensing processes. The graphical representation of the PEO-ARIS modelling output can assist its end user to create a comprehensive overview on the entire processes, as well as on the modelling fragments' objective(s). More importantly, the ARIS modelling output has the capability of enabling the PEO's perspective applicants to understand the main regulations that drive the processes toward achieving its desired goal. This is a potential benefit of the ARIS modelling output since it will play a major rule in avoiding delaying the evaluation process since its end user has fully captured all its requirements.

Over all, it has been concluded that the PEO-ARIS model has favourably detailed sufficient information of the "AS-IS" current PEO legislated licensing processes through the main four different views of the PEO, covering the entire life cycle.

5.1.2 Automotive Manufacturing Processes Case Study

The (Crash Data Retrieval System) is an innovative product that allows anyone with a computer to download the embedded vehicle-specific accident data. While initiating the mission to work on this case study, the question that crossed to my mind was as follows: what is the probability that the output from the CDRS analysis will be acceptable legal evidence? The answer of this question is highly dependent on so many issues and measurable criteria. It is believed that applying the SAD methodologies to better represent the CDRS processes mechanism will assist to better answer the previous question. It is the achievement of such modelling work that assists in representing all necessary data and information used by the accident's re-constructionists.

Applying the SAD methodologies as illustrated in this case study was intended to understand which methodology(s) was capable of detailing the CDRS mechanism. In addition to selecting the processes methodology(s) that addresses most critical measuring criteria (Efficiency of its performance in its complex environment nature). That will be the first step to redesigning (BPR) the business processes for achieving dramatic improvements in critical measures of performance.

As previously mentioned, Hammer [1990] and Hammer and Champy [1993] have considered process reengineering as a fundamental rethinking and redesign of business processes. This is to achieve dramatic improvements in critical measures of performance such as cost, quality, and service. Up to this level of following the key steps of implementing a BPR strategy sourced from Fitzgerald [2002], the processes have been understood through its modelling work performed earlier. The work to follow is mainly based on the stated most critical measuring criteria which is measuring CDRS quality of its performance in its complex environment. This will be followed by identifying the action plan to improve the system's quality where the limitation of this work will reach to this step. Future work however might include extending this research through executing the actions plan and measuring its output performance for the conducted CDRS BPR.

Although it has been determined from the literature to be one of the methodology's deficiencies [Saven, 2003], the so many notations within the CDR-$IDEF_0$ model have assisted in understanding the CDRS processes inputs, outputs, mechanisms and controls. The hierarchical structure of the CDR-$IDEF_0$ model has resulted in quick mapping at a high level. The CDRS processes sequencing has been illustrated in the $IDEF_0$ - AI0WIN7 model. That successfully identified opportunities for improvements while revealing data and information relationships from the CDRS device. This has resulted in a detailed description for demonstrating how the system functions at certain event, what things it is linked with, and also what type of expected output together with its specific supportive format.

One of the main capabilities of the $IDEF_0$ approach for modelling the CDRS; is its ability in identifying errors and problems in an early state of the CDR system's design. This is due to the variety of its components and relationships between them. Using the $IDEF_0$-AI0WIN7 has resulted in successfully specifying its system's requirements before analyzing its key elements for decision-making by the accident re-constructionists.

Although, the $IDEF_0$-AI0WIN7 has proven its effectiveness for BPR the CDRS, the resulted model was technically concise and appeared to be modeled only for domain experts. However automobiles drivers need to be considered as a major model observer too. This object-oriented methodology was capable in effectively presenting the measuring criteria of the system's functionality.

This is because of the so many notations resulted from decomposing the process to be evaluated with. In other words, the CDR-$IDEF_0$ model was capable of detecting where resources might need to be reallocated by realizing the processes that can be considered as critical for reengineering the CDR system. This is mandatory for improving its usefulness when used by the accident's re-constructionists. This is the first step required before proceeding with setting the action plan for the product's BPR.

The capability of the implemented subjective oriented methodology (LOVEM) can be viewed from the accidents re-constructionists perspective when assigned the monitoring eye. This will potentially assist in detecting errors and problems in an early state of the CDRS modelling. At the stage of reengineering the interactions of the systems elements, system's developers can determine criteria for optimizing its subjective performance. This is because of the ability to include the (CDRS' CMP), (CSF), and also (GSP) by using the LOVEM in ADAONIS tool kit.

The CDR-ARIS modelling capability can be explained through its effectiveness in realizing all aspects associated with the CDRS mechanism. Subjectively, that has resulted in a data/information model considered to be a keystone for a systematic and intelligent method of developing application systems, focusing on improving the efficiency of the CDRS mechanism.

In addition to the CDR-ARIS neither provided means to validate the resulted model nor sequence of the information was embedded, it was not capable of identifying rich set of errors and problems in the early state of the system modelling. This is particularly in comparisons with the CDR-$IDEF_0$ resulted model. In this case study, the so many notations included in the $IDEF_0$ modelling output have assisted in capturing all necessary information to understand its objective and use through its end user (e.g. accident re-constructionists) .One major concern however can be considered to be one of the $IDEF_0$ approach deficiencies. It is the environment which modelling the CDRS mechanisms needs to address. The fact is that the CDRS processes are subject to other factors beyond data and information stored on the device. Subjectively not objectively, that will include the claimed to be an accident witness, conflict of expert's opinions, as well as crucial keys required for synthesising all facts. Using the LOVEM and ARIS processes modelling approaches is believed to complement this need, which $IDEF_0$ lacks in addressing this mandatory type of information. This is certainly due to the desired output of the CDRS device.

Table 5.2 provides a summary of the detailed discussion of the implemented processes modelling methodologies including ($IDEF_0$, LOVEM, and ARIS) in the second case study is presented next. It focuses on addressing the processes modelling approach, capabilities and deficiencies detected after evaluating the modelling output resulted from using the modelling tool kits including (AI0WIN7, ADONIS and LOVEM in ADONIS, and ARIS).

Table 5.2: Summary Of The Output Approach, Capabilities, And Deficiencies Of The Implemented Processes Modelling Methodologies In The Automotive Engineering Modelling Case Study (Continue)

Technique	Objective	Approach Output	Capabilities	Deficiencies
CDR-$IDEF_0$ Model (AI0WIN7 Tool Set)	Object Oriented Approach for Identifying opportunities for BPR the CDR System While Revealing Data and Information Relationships from its device.	Easy Overview Representation and Control of Performance Shows the Inputs, Outputs, Control and Mechanisms Overview and Details of the CDR System.	Effective in Detailing the CDR System's Activities for Function Modelling. Identifying Errors and Problems in an Early Stage of the Product Design. Detecting Where Resources Might Need to be Reallocated by for improving the CDR output. ABC Modelling is Enabled. Simulation Component Such as $IDEF_2$	Rigid (When Compared to LOVEM/ARIS) Hierarchical Structuring That includes A lot of Notations. Domain Experts Might be Required for technical Terms explanations. Non Domain Experts Might Interpret the Model as a Sequence of the CDR System Activities. Doesn't Include any Animation Component in Order to Do Some Pre-Calculation of

			Can be Imported From KBSI's Library Management. High Capability of the Modelling Output Generated Report Using AI0WIN7 Tool Kit.	Possible Results in Reality. Doesn't Enhance Abstractions Provided by Lines. Only Focus on Rectangles' Abstraction.
ADONIS BPM* Standard Tool Kit And CDR-LOVEM Model	Innovate Business Processes, Analyze and Design Organization, Workflows, and Staffing Requirements.	Explicitly Representing the Monitoring eye of the Accidents Re-Constructionist of the CDR System's Mechanisms. Exploring the CDR System's Mechanism and how the Accident re-Constructionists Deploy it, and Monitor its Performance.	Upper Eye' View assigned to the Accidents Re-Constructionists Who Will Assist in Detecting Errors and Problems in an Early State of the CDR System's Modelling. Includes Animation Component in order to Do Some Pre-Calculation of Possible Results in Reality. Intermediate Level of Capability of the Modelling Output Generated Report Using ADONIS Tool Kit.	Not Enough Notations to Support Favourable Measuring Criteria Evaluation. Non-Domain Experts Might Interpret the Model as a Sequence of How the Accidents Re-Constructions Use the CDR System in All Situations. Only Focuses on One Main Eye to Monitor of Processes. Domain Experts Might be Required for Technical Terms explanations.

			Simulation Component (ARENA) Can be Imported From ADONIS Library Management. ABC Modelling is Enabled.	
CDR-ARIS Model (ARIS Tool Set)	Representing the CDR System's Mechanism and Improve its Performance through its all Life Cycle.	Distinguishing Between the Device Function, Data, and Processes Views. A Well-Documented Methodological Framework to Enable Supporting the Entire Device Manufacturer During its all Life Cycle Phases. Achieve Optimized CDR's Processes Performance.	Realizing All Aspects Associated with the CDR System's Mechanism. Provided A Well Documented Methodological Framework to Enable Supporting the Entire CDR System's Mechanism During its all Life Cycle Phases. Includes Animation Component in Order to Do Some Pre-Calculation of Possible Results in Reality. Intermediate Level of Capability of the Modelling Output Generated	Non Domain Experts Might Interpret the Model as a Sequence of How the Accidents Re-Constructions Use the CDR System in All Situations. Domain Experts Might be Required for technical Terms explanations.

			Report Using ADONIS Tool Kit. Simulation Component (ARIS Simulation Module) Can be Imported From ARIS Library Management. ABC Modelling is Enabled.	

Table 5.2: Summary Of The Output Approach, Capabilities, And Deficiencies Of The Implemented Processes Modelling Methodologies In The Automotive Engineering Modelling Case Study (Continue)

As described above, the SAD methodologies implemented in the second case study, have their capabilities as well as deficiencies related particularly when modelling the CDRS processes mechanisms. This will be objectively and subjectively reflected in the CDRS-BPR action plan to be developed by its domain experts. This will be achieved when selecting the determined to be comprehensive existing processes model that addresses the system's measuring performance criteria and can successfully excite its desired output.

The analysis conducted has justified the fact that the action plan to be taken by the systems develops, is subjectively dependent on the monitoring eye (accidents re-constructionists) of the CDRS mechanisms through the CDR-LOVEM developed model. This modelling output can be considered as a favourable piece of information for the CDR's manufacturer. It can potentially assist to establish more measurable criteria for improving its usefulness when by its end user.

This doesn't eliminate the usefulness of the CDR-ARIS model, which favourably assisted in detailing the main views of the CDRS through its all life cycle phases. The main capabilities of its modelling output can be explained through the graphical explicit views ARIS model provided to its main domain experts. This will potentially assist in detecting and understanding where complexity exists in these processes such as uncertainty of data analysis output particularly when it conflicts other resulting output.

Over all, this evidence is highly considered to be insufficient if not objectively and subjectively modeled, designed, and released to its domain interest.

5.2 Results and Conclusions

As a result of new customers' demands as well as market competition, business environment is continuously changing. This indicates the need for managing the uncertainty and complexity of the improved/ reengineered business and manufacturing processes. In other words, the management of the complexity within the new business designs needs to be considered as mandatory requirements. This is to assist business managers to ensure an efficient and effective business design processes management.

A business process is the combination of a set of activities within an enterprise with a structure describing their logical order and dependence whose objective is to produce a desired result. The BPM enables a common understanding and analysis of a business process. A process model can provide a comprehensive understanding of a process. Processes modelling methodologies have proven its effectiveness, in capturing all useful information included within the enterprise business processes.

It can be stated, that if the process model is considered a correct representation of the process logic, a modelling tool can help with verifying whether the process, as designed and implemented, will meet its target(s). Once the process model is implemented, various execution measurements can be monitored. The process performance monitor will collect and represent the actual behaviour of the processes.

Three main comprehensive design methodologies ($IDEF_0$, LOVEM, and ARIS) have been selected and implemented through their tools (AI0WIN7, ADONIS/ LOVEM in ADONIS, and ARIS). Such tools have assisted with integrating the selected enterprise through modelling its business activities, technology and human elements' objectively and subjectively involved.

The implementations of the SAD methodologies have been demonstrated on two case studies in this thesis. In addition, quantification analyses and comparisons of the implemented SAD methodologies and tools have been presented in Table 5.3 presented next:

Table 5.3: Comparisons Of The Implemented Systems Analysis And Design Methodologies And Tool Sets

Measuring Criteria / Modelling Methodology and Tool	Tool's Compliance with Methodology	Ease of Installation	Ease of Learning and Use	Ease of Editing Modeling Content	Capability of Selecting Interface Based on Business Environment	Capability of Dealing with Design Objective Based on Business Environment	Capability of Improving Modeling Output Quality Based on Business Environment	Capability of the Generated Report	Capability of Including Activity Based Cost Calculation	Capability of Including Animation Component	Capability of Performing/ or Linking Model to Simulation Tool	Criteria Performance Evaluation	
IDEF0 Methodology	0	0	7	0	0	Business Case = 7 Eng. Case = 10	Business Case = 7 Eng. Case = 10	0	0	0	0	Business Case = 21 Eng. Case = 27	IDEF0 Business Case Model = 106 IDEF0 Eng. Case Model = 118
AI0WIN7 Process Modelling Tool	7	10	10	2	2	Business Case = 7 Eng. Case = 10	Business Case = 7 Eng. Case = 10	10	10	0	10	Business Case = 85 Eng. Case = 91	
Line of Visibility Methodology	0	0	7	0	0	Business Case = 7 Eng. Case = 7	Business Case = 7 Eng. Case = 5	0	0	0	0	Business Case = 21 Eng. Case = 19	LOV Business Case Model = 91 LOV Eng. Case Model = 89
ADONIS Process Modeling Tool	10	2	7	7	5	Business Case = 5 Eng. Case = 5	Business Case = 5 Eng. Case = 5	2	10	7	10	Business Case = 70 Eng. Case = 70	
ARIS Modeling Framework	0	0	7	0	0	Business Case = 10 Eng. Case = 5	Business Case = 10 Eng. Case = 7	0	0	0	0	Business Case = 27 Eng. Case = 19	ARIS Business Case Model = 129 ARIS Eng. Case Model = 113
ARIS Process Modelling Tool	10	10	7	10	10	Business Case = 10 Eng. Case = 7	Business Case = 10 Eng. Case = 5	5	10	10	10	Business Case = 102 Eng. Case = 94	

Low = 2 , Medium = 5 , Intermediate = 7 , High =10

The modelling output of the two case studies has proven that each one of the implemented SAD methodologies and tools has its capabilities as well as deficiencies according to the key concern of the implemented case studies. This is also in how it deals with the design objective and also in whether or not it has assisted in improving the modelling quality.

The output of the PEO-IDEF$_0$ model was composed of a hierarchical series of diagrams, text, and glossary cross-referenced to each other. Comparing with the traditional flow-charting representations, the IDEF$_0$ function modelling language was capable of graphically representing a wide variety of the PEO's licensing processes procedure together with its entire network communications to any level of detail. Also, its many notations were capable in addressing all activities associated with the PEO's licensing processes procedure.

It has been concluded that this model is highly dependent on its domain experts or the ones who participated in the developed model. The fact the IDEF$_0$ language doesn't enhance abstractions provided by its interfaces such as mechanisms, this has raised some concerns of its modelling output quality. This is particularly when there is a contention for resources to perform the PEO's legislated activities. This concern was implicitly included and left for domain experts to recognize it. In addition, the PEO-IDEF$_0$ modelling output didn't explicitly detect where resources might need to be reallocated by realizing the performed activities that might be subject in delaying the PEO's perspective applicant's application.

The automatically generated report while using the IDEF$_0$-AI0WIN7 tool can be considered as a main capability of this approach. This can be viewed from three perspectives. Its ability in linking the input, output, mechanism, and control contents associated with any activity together with its decomposed ones is first. Second is its features by including the associated reference of the [R.R.O 1990 (R.R.O); R.S.O 1990 (R.S.O)], with hierarchy of the top-level diagrams. Such associated references have represented the overall structure of the processes. In addition, the bottom-level ones have represented its detailed structure. Immense reduction in time and efforts were achieved while implementing the PEO-$IDEF_0$ model using the AI0WIN7 when compared with the PEO- MS power point model.

Adding to the conclusive fact that the LOVEM-BPM technique didn't explicitly embed a second monitoring eye in its structure, it didn't focus on how many monitoring eyes need to be embedded and which one(s) to be considered the highest weighted one(s). This is required for evaluating the assigned resources and efforts dedicated for the PEO's licensing process. That includes the functions related to setting standards (PEO's Quasi-Legislative) against those functions associated with the administration of standards (PEO Quasi-Judicial Powers).

In addition, the PEO-LOVEM modelling output, using the ADONIS tool kit, has assisted in recognizing all PEO's business rules and policies including the (CMP), (CSF), as well as the (GSP). This has particularly assisted in analysing and redesigning interactions between the PEO's perspective applicants and the mechanisms of the PEO's licensing process procedure.

The PEO-ARIS modeling output was capable of distinguishing between the PEO's council, its function, information, and control views. This expanded view has provided a well and easy to learn a documented methodological framework. This is to enable supporting the entire PEO's council licensing process during its all life cycle phases. It has been concluded that the PEO-ARIS model has detailed sufficient information of the "AS-IS" current PEO legislated licensing processes through the main four different views of the PEO Council to cover the entire modelling life cycle.

The quantification analysis illustrated in Table 5.3., has indicated that the PEO-$IDEF_0$ modelling capability in dealing with improving and optimizing the PEO's processes execution was more favourable when compared with the PEO-LOVEM model. The implementation of the LOVEM methodology through ADONIS tool was not capable enough when compared to the other two methodologies. This is mainly in detecting where "Processes Delays" might be a major factor resulting in the PEO's applicants' dissatisfaction.

After evaluating the ease of learning, deploying, and gain an understanding on the capability of the ARIS framework/ tool set, it has been concluded that the PEO-ARIS model has favourably detailed sufficient information of the current PEO legislated licensing process. In addition, its flat process's modelling output was more capable in capturing all aspects associated with the PEO licensing procedure. The point to make in this part is as follows: the PEO-ARIS modelling output has the capability of capturing a rich set of information assisting the PEO's perspective applicants to gain better understanding on the process's procedure. The modelling output enables its reader to gain a better understanding on the nature of the PEO procedure while administering the licensing process.

This is a very necessary criteria needs to be addressed to assure having a correct modelling output that represent the logic of the legislated process. The first reason is to justify whether or not the current licensing procedure is meeting the Government of Ontario's legislation target. The second one is to deliver a clear picture of the licensing procedure to the PEO's perspective applicants to have better understanding where delay might carry on with their application and what criteria need to be met before they apply for obtaining the P. ENG license.

Implementing the three design methodologies for modelling the CDRS processes' mechanism has brought different conclusion for the SAD methodology(s) selection. This has justified the stated assumption that processes modelling are highly dependent on the processes environment and measuring criteria desired to visibly detect before proceeding with the action plan.

In this case study, reengineering the CDRS mechanism is subject to other factors beyond data and information stored on the device. It has been concluded that the $IDEF_0$

was capable in effectively presenting the measuring criteria of improving the device efficiency. The action plan to be taken by the systems develops is highly dependent on the monitoring eye (accidents re-constructionists) of the CDRS mechanisms through the CDR-LOVEM developed model.

The output of the CDR-ARIS model can be considered as an asset for the CDRS developers. This is required particularly when linking the monitoring eye view to the other views ARIS integrated in its representation. This is considered as a justification for objectively and subjectively basing the reengineered action plan for successfully improving the CDRS mechanisms' efficiency and successfully executing its modelling output. After conducting the quantitative analyses as illustrated in figure 5.3, it has been determined that the CDR-$IDEF_0$ modelling output was more capable in effectively presenting the measuring criteria of the second case study.

This is particularly for representing its existing functioning processes while deployed by the accident re-constructionists. The major goal out of the desired modelling output is to redesign its functioning processes for achieving dramatic improvement of its performance quality. Such plan is considered to be critical and it is highly dependent on its domain experts as well as available technology.

5.3 Further Research

The business processes are changing so fast and so inconsistently because of the complexity in accommodating the pressure of new customers demand, market competition, and introduction of new products and services to survive in such volatile global unstable market on the long term [ElMaraghy, 2003 (a)].

That makes it mandatory to dedicate potential efforts and resources for conducting further research work to analyse in details the available process modelling approaches as well as tools. This is for developing a comprehensive design methodology that captures all necessary information to cooperating in pursuit of optimized enterprise performance and achieving corporate strategic goals [Hammer, 2003].

Integrating the surveyed SAD methodologies can be considered as a promising area of system's design research interest to conduct. Including the nature of the design methodology, this work can be considered as an approach to integrate the capabilities of the available traditional flow charting and current processes modelling approaches.

The desired objectives of this work can be successfully reached when research will be dedicated for determining other industry-processes modelling complexity-criteria. The question that has been asked earlier and its desired answer is believed to be still pending, is determining What Makes Processes Complex? The literature has linked the answer to the variety of the elements and relationships between them in the business processes. It is believed that there should be other criteria that need to be considered. This is while any efforts taken, for managing the complexity in business and manufacturing processes.

Finally, a potential future research can be initiated for embedding SAD-intelligence to automatically detect, select, and trigger the right design methodology to the associated BPM problem. This is based on a given weighted processes-complexity criteria. This is considered to be a promising collaborative design research. Its objective will be to stimulate effective behaviour of the processes complexity, where their redundancies and bottlenecks can be captured. In addition, they can be linked with embedded decision support analyses. Such decision will be automatically triggered to evaluate and determine systems design engineering responsiveness to be taken by the systems development team.

REFERENCES

1. Arbab, F., Marcello B, Juan S, Maria I, Henk J, Marc L, Erik, P, And Andries S, 2002, "State Of The Art In Architecture Frameworks And Tools", Telematica Institute, The Netherlands.

2. Architecture of Integrated Information Systems (ARIS), 2004, URL: Http://www.Ids-Scheer.Com/.

3. Bauer, M., 1992, "The Very Beginning of Analysis and Development", Journal of Systems Management, Vol. 43, No. 12, pp. 37-40.

4. Bentley, L., Jeffrey W and Kevin D., 2001, "System Analysis and Design Methods", McGraw-Hill, USA.

5. Berio, G., and Verndat, F B., 1999, "New developments in enterprise modelling using CIMOSA", University of Mitz, Vol. 40, pp. 99-114.

6. Biemans, F., Lankhorst M, Teeuw W, and Van De Wetering Rg., 2001, "Dealing with the Complexity Of Business Systems Architecting", Systems Engineering Vol. 4, No. 2, pp. 118-133.

7. BOC Information Technologies Consulting Ltd. (BOC), 2004, "Adonis Business Process Management Toolkit" BOC, Austria.

8. BOC ITC GmbH, 2004, "Line of Visibility In Adonis Installation Procedure", Vol. 5, No. 3.0x, pp. 1-149.

9. Boucher, X., Harld K, and Jane J, 2003, Integrated Modelling And Simulation Of Inter-Organizational Business Processes, MoSim' 03, France.

10. Burlton, R., 2001, "Business Process Management", Sams Publishing. Inc, USA.

11. Business Improvement Software Pty Ltd. (BIS), 2004, "Description Of $IDEF_0$", URL: Http://Www.Bisoft.Com.Au/Idef0.Htm.

12. Crash Data Retrieval System, URL: http://www.vetronix.com/ppt/brochures/CDR_Overview.ppt

13. Davenport, T., 1993. "Process Innovation: Reengineering Work through Information Technology", Harvard Business, USA.

14. Dixon, J., and Corrado P, 1995, "Engineering Design and Design For Manufacturing", Field Stone, USA.

15. Doppler, K., and Christopher L., 2001, "Managing Corporate Change", Springer, Germany.

16. Draft Federal Information Processing Standards Publication (FIBS), 1993, "Announcing the Standard For Integration Definition For Function Modelling ($IDEF_0$)", US DOD, USA.

17. ElMaraghy, W, 2000 (a), "System Analysis and Design: An Approach To Information Based Design Process Modelling", CIRP, Canada.

18. ElMaraghy, W., 2003 (b), "Class Notes Of IMSE 91-514' Engineering Design, Methodology and Applications", University Of Windsor, Canada.

19. ElMaraghy, W., 2003 (c), "Holistic Engineering Design: A Strategy for Managing Manufacturing Complexity, Intelligent Manufacturing Systems (IMS) Centre, Canada.

20. Ertas, A., and Jesse J., 1993, "The Engineering Design Processes, John Wiley and Sons. Inc., USA.

21. Fitzgerald, D., 2002, "Business Process Reengineering", Oak Training Ltd., Ireland.

22. Frizelle, G., 1998 "The Management of Complexity in Manufacturing", Business Intelligence, UK.

23. Hammer, M., 1990, "Reengineering work: Don't automate. Obliterate", Harvard Business Review, Vol. 68, No. 4, pp. 104–112.

24. Hammer, M., 2003, "Business Process Change Management". ARIS in Practice, Springer, Germany.

25. Hammer, M., and Champy, J., 1993, "Reengineering the Corporation", Harper Business, USA.

26. IBD Innovative Business Design Designs Business, 2004, URL: http://www.innovativebusinessdesign.com/, Australia.

27. IDS-Scheer Profile, 2004, URL: Http://Www.Aris-Toolset.De/English/Index.Php.

28. IDS-Scheer, 2003, "ARIS Framework Concept", IDS-Scheer, Germany.

29. KBSI Research and Development Centre (KBSI), 2002, "Smart Set User's Manual Knowledge Based Systems, Inc.", KBSI Inc, Vol. 2.4, pp. 1-18.

30. Knowledge Based Systems Inc. (KBSI), "Engineering and Business Process Design and Development, URL: Http://Www.Kbsi.Com/Solutions.Htm.

31. Knowledge Based Systems Inc. (KBSI), 2000, "IDEF$_0$ Overview", URL: http://www.idef.com/idef0.html.

32. Knowledge Based Systems, Inc. (KBSI), 2000, "KBSI's Business Evolution Strategies and Tactics", KBSI, USA.

33. Kosanke, K., 2000, "Business Process Modelling and Standardisation", CIMOSA Association E.V, Germany.

34. Leong, A., 2000, "IDEF Modelling Methodology for Development Of Manufacturing Enterprise Systems", URL:http://www.simtech.a-star.edu.sg/research/tech-report2000.html.

35. Line Of Visibility Enterprise Modelling, URL#1: Http://Www-1.Ibm.Com/Services/Bis/Lovem/, URL#2: Http://Www-1.Ibm.Com/Services/Files/Lovem_Overview.Pdf.

36. National Highway Traffic Safety Administration, 2004, URL: http://www.nhtsa.dot.gov/.

37. Noran, O., 2004, "UML Vs. IDEF", Griffith University, Australia.

38. Nye, T., 1997, "Simultaneous Improvement in Manufacturing Systems and Effect on Investment Decisions", University Of Waterloo, Canada.

39. Ould, M., 1995, "Business Processes: Modelling and Analysis for Re-Engineering and Improvement", Wiley, Chichester.

40. Pearson, T., 1999, "Measurements and the Knowledge Revolution", American Society for Quality, Vol. 32, No. 9, pp. 8.

41. PEO Council, 2004, "Professional Engineers Act - R.R.O. 1990, Regulations 941", URL: Http://192.75.156.68/Dblaws/Regs/English/900941_E.Htm.

42. PEO Council, 2004, "Professional Engineers Act - R.S.O. 1990, Chapter P.28", URL: Http://192.75.156.68/Dblaws/Statutes/English/90p28_E.Htm#P110_1871.

43. PEO Council, 2004, URL: http://www.peo.on.ca/.

44. Pratten, G., 1997, "Illustrating Problems with $IDEF_0$", URL: http://www.prattens.co.uk/webposd/posdg/posdg.htm

45. Research Development Centre, National Highway Traffic Safety Administration Website, URL: http://www-nrd.nhtsa.dot.gov/edr-site/media.html.

46. Rosemann, P., 2000, "Integrated Process Modelling: An Ontological Evaluation", Information System, Vol. 25, No. 2, pp. 73-87.

47. Saven, R., 2003. “Business Process Modelling: Review and Framework”, International Journal of Production Economics Vol. 90, pp. 129-149.

48. Schaller, M., 2001, “Successfully Building Enterprise Architectures, How ARIS Facilitates the Zachman Framework”, Leonardo Consulting, Australia.

49. Scheer, A., 1992, “Architecture of Integrated Information Systems”, Springer, Germany.

50. Simon, K., 1994, “Towards a theoretical framework for Business Process Reengineering”, Göteborg University, Sweden.

51. Sola, H., Alexander V., Douglas, V., and Gert-Jan, V., 2000," Collaborative Engineering of Processes and Systems Introduction to the Minitrack", Hawaii International Conference on System Sciences, USA.

52. Sparks, G., 2000, “An Introduction to UML – The Business Process Model”, Sparks Systems, Australia.

53. Suh, N., 1999, “A Theory of Complexity, Periodicity and the Design Axioms”, Massachusetts Institute of Technology, Vol. 11, pp. 116-131.

54. Tétard, T., 2004, “Business Processes and Information Systems”, Institute For Advanced Management Systems Research, USA.

55. The CIMOSA Association, 1996, “CIMOSA, A Primer on key concepts, purpose and business value”, URL: http://cimosa.cnt.pl/Docs/Primer/primer5.htm.

56. Trautmann, W., 2000, “Executive Summary of A LOVEM Project”, IBM, Canada.

57. Underdown, D., 1999, “An Enterprise Transformation Methodology” The University Of Texas at Arlington, USA.

58. Vernadat, F., 1996. “Enterprise Modelling and Integration: Principles and Applications”, Chapman and Hall, UK.

59. Voland, G., 2001, “Engineering By Design”, Addison-Wesley, USA.

60. Williams, T., 2000, “CIMOSA - European Enterprise Integration Concept”, URL: http://www.pera.net/Arc_cimosa.html

61. Zachman, J., 1999, “A Framework for Information Systems Architecture”, IBM Systems Journal, Vol. 38, No. 2/3, pp. 454.

APPENDIX A

GENERATED ARIS REPORT OF THE PROFESSIONAL ENGINEERS COUNCIL LICENSING PROCEDURE MODEL

IDS SCHEER	Model objects in the modeled sequence	ARIS 6 Collaborative Suite

****

ARIS REPORT

****

Server: Local
Database: Demo62
User: Anas Kazaal

****

PEO Application processing

****

Start path
Applicant's Contact with PEO Council, Event
Structurally relevant relationships:
Activates Open New Application File

Open New Application File, Function
Structurally relevant relationships:
is activated by Applicant's Contact with PEO Council
is predecessor of Forward Application For Academic Assessment

Forward Application For Academic Assessment, Function
Structurally relevant relationships:
follows Open New Application File
Is predecessor of Evaluate Applicant's Academic Background (Mark 0)

Evaluate Applicant's Academic Background, Function (Mark 0)
Structurally relevant relationships:
Follows Forward Application for Academic Assessment
Is activated by Experiential Learning Assessment Is Not Satisfactory
Is activated by Experiential Learning Assessment Is Satisfactory (Mark 1)
Leads to Rule (Mark 2)

Rule, Rule (Mark 2)
Structurally relevant relationships:
Is assigned to Evaluate Applicant's Academic Background (Mark 0)
Leads to Academic Background Is Satisfactory

Leads to Academic Background IS NOT Sufficient But MIGHT BE Considered
Leads to Academic Background Is Not Satisfactory

Academic Background IS NOT Sufficient But MIGHT BE Considered, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 2)
Activates Forward Application for Experiential Learning Review

Forward Application for Experiential Learning Review, Function
Structurally relevant relationships:
Is activated by Academic Background IS NOT Sufficient But MIGHT BE Considered
Is predecessor of Perform Experiential Learning Assessment?

Perform Experiential Learning Assessment, Function
Structurally relevant relationships:
Follows Forward Application For Experiential Learning Review
Leads to Rule (Mark 3)

Rule, Rule (Mark 3)
Structurally relevant relationships:
Is assigned to Perform Experiential Learning Assessment
Leads to Experiential Learning Assessment Is Satisfactory (Mark 1)
Leads to Experiential Learning Assessment Is Not Satisfactory

Experiential Learning Assessment Is Satisfactory, Event (Mark 1)
Structurally relevant relationships:
Is dependent on Rule (Mark 3)
Activates Perform Over All Applicant's Work Experience Assessment
Activates Evaluate Applicant's Academic Background (Mark 0)

Perform Over All Applicants' Work Experience Assessment, Function
Structurally relevant relationships:
Is activated by Experiential Learning Assessment Is Satisfactory (Mark 1)
Leads to Rule (Mark 4)

Rule, Rule (Mark 4)
Structurally relevant relationships:
Is assigned to Perform over All Applicant's Work Experience Assessment
Leads to Work Experience Background Is Satisfactory
Leads to Work Experience Background Is Not Satisfactory

Work Experience Background Is Satisfactory, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 4)
Activates Administer Professional Practice Examination Program (PPE) (Mark 5)

Administer Professional Practice Examination Program (PPE), Function (Mark 5)
Structurally relevant relationships:
Is activated by Applicant Has Passed the PPE Test (Mark 6)
Is activated by Work Experience Background Is Satisfactory
Is activated by Academic Background Is Satisfactory
Is activated by Applicant Has Failed/ Failed to Appear the PP Test (Mark 7)
Leads to Rule (Mark 8)

Rule, Rule (Mark 8)
Structurally relevant relationships:
Is assigned to Administer Professional Practice Examination Program (PPE) (Mark 5)
Leads to Applicant Has Passed the PPE Test (Mark 6)
Leads to Applicant Has Failed/ Failed To Appear the PP Test (Mark 7)

Applicant Has Passed the PPE Test, Event (Mark 6)
Structurally relevant relationships:
Is dependent on Rule (Mark 8)
Activates Administer Professional Practice Examination Program (PPE) (Mark 5)
Activates Perform Final Licensing Assessment and PEO Decision Making

Perform Final Licensing Assessment and PEO Decision Making, Function
Structurally relevant relationships:
Is activated by Applicant Has Passed the PPE Test (Mark 6)
Is predecessor of Contact Applicant for Notification (Mark 9)

Contact Applicant for Notification, Function (Mark 9)
Structurally relevant relationships:
Is activated by Academic Background Is Not Satisfactory
Is activated by Applicant Has Failed/ Failed to Appear the PP Test (Mark 7)
Follows Perform Final Licensing Assessment and PEO Decision Making
Follows Assign Engineering in Training Program To Applicant
Creates Notification is being Delivered

Notification is being Delivered, Event
Structurally relevant relationships:
Is created by Contact Applicant for Notification (Mark 9)
End path

Start path
By Mark 8
Applicant Has Failed/ Failed To Appear the PP Test, Event (Mark 7)
Structurally relevant relationships:
Is dependent on Rule (Mark 8)
Activates Contact Applicant for Notification (Mark 9)
Activates Administer Professional Practice Examination Program (PPE) (Mark 5)

Start path
By Mark 4
Work Experience Background Is Not Satisfactory, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 4)
Activates Assign Engineering In Training Program to Applicant

Assign Engineering in Training Program to Applicant, Function
Structurally relevant relationships:
Is activated by Work Experience Background Is Not Satisfactory
Is predecessor of Contact Applicant for Notification (Mark 9)

Start path
By Mark 3
Experiential Learning Assessment Is Not Satisfactory, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 3)
Activates Evaluate Applicant's Academic Background (Mark 0)

Start path
By Mark 2
Academic Background Is Not Satisfactory, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 2)
Activates Contact Applicant for Notification (Mark 9)

Start path
By Mark 2
Academic Background Is Satisfactory, Event
Structurally relevant relationships:
Is dependent on Rule (Mark 2)
Activates Administer Professional Practice Examination Program (PPE) (Mark 5)

****

IDS SCHEER	Model objects in the modeled sequence	ARIS 6 Collaborative Suite

APPENDIX B

GENERATED ARIS REPORT OF THE CRASH DATA RETRIEVAL SYSTEM MODEL

IDS SCHEER	Model objects in the modeled sequence	ARIS 6 Collaborative Suite

****
ARIS REPORT
****

Server: local
Database: Demo62
User: Anas Kazaal

Crash Data Retrieval (CDR) System

Start Path
Recording Vehicle Pre-Crash Data, Function
Structurally Relevant Relationships:
Creates Vehicle Pre-Crash Data Are Stored In The CDR Device

Vehicle Pre-Crash Data Are Stored In The CDR Device, Event
Structurally Relevant Relationships:
Is Created By Recording Vehicle Pre-Crash Data
Activates Recording Vehicle Post-Crash Data

Recording Vehicle Post-Crash Data, Function
Structurally Relevant Relationships:
Is Activated By Vehicle Pre-Crash Data Are Stored In The CDR Device
Creates Vehicle Post-Crash Data Are Stored In The CDR Device

Vehicle Post-Crash Data Are Stored In The CDR Device, Event
Structurally Relevant Relationships:
Is Created By Recording Vehicle Post-Crash Data
Activates Perform Data Analysis, Investigation And Verifications (Mark 0)

Perform Data Analysis, Investigation And Verifications, Function (Mark 0)
Structurally Relevant Relationships:
Follows Perform More Investigation And Verifications
Is Activated By Vehicle Post-Crash Data Are Stored In The CDR Device
Creates Crashed Vehicle Data Analyzed, Investigated, And Verified

Crashed Vehicle Data Analyzed, Investigated, And Verified, Event
Structurally Relevant Relationships:

Is Created By Perform Data Analysis, Investigation And Verifications (Mark 0)
Is Evaluated By Xor Rule (Mark 1)

Xor Rule, Rule (Mark 1)
Structurally Relevant Relationships:
Evaluates Crashed Vehicle Data Analyzed, Investigated, And Verified
Activates Evaluate Data And Release Output To Law Enforcement (Mark 2)
Activates Perform More Investigation And Verifications

Evaluate Data And Release Output To Law Enforcement, Function (Mark 2)
Structurally Relevant Relationships:
Is Activated By Xor Rule (Mark 1)
Follows Report Printing
Follows Simple Graphs And Tables
Creates Data Analyses And Verifications Conducted

Data Analyses And Verifications Conducted, Event
Structurally Relevant Relationships:
Is Created By Evaluate Data And Release Output To Law Enforcement (Mark 2)
End Path

Start Path
By Mark 1
Perform More Investigation And Verifications, Function
Structurally Relevant Relationships:
Is Activated By Xor Rule (Mark 1)
Is Predecessor Of Perform Data Analysis, Investigation And Verifications (Mark 0)

Start Path
Simple Graphs And Tables, Function
Structurally Relevant Relationships:
Is Predecessor Of Evaluate Data And Release Output To Law Enforcement (Mark 2)

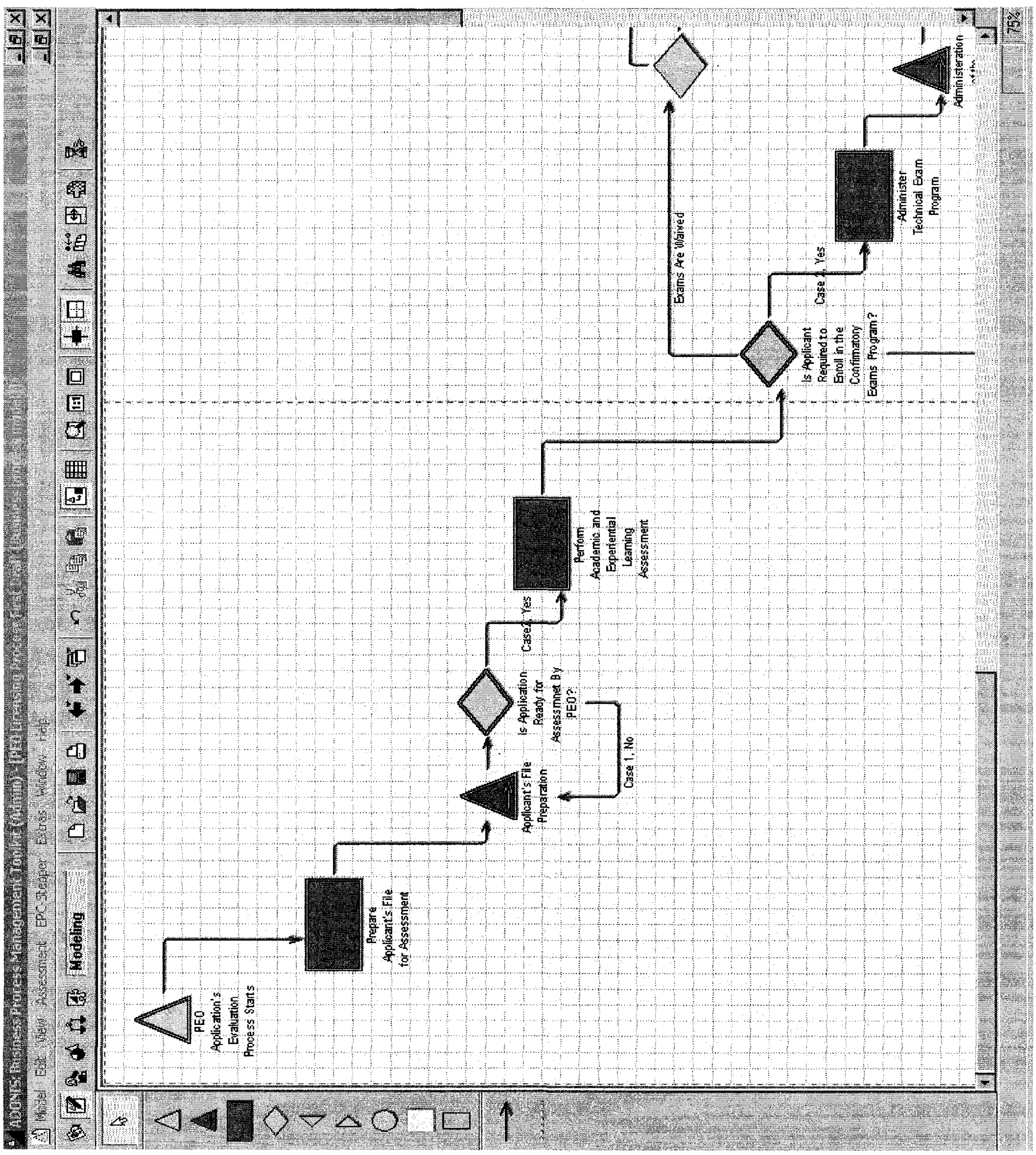
Start Path
Report Printing, Function
Structurally Relevant Relationships:
Is Predecessor Of Evaluate Data And Release Output To Law Enforcement (Mark 2)

****

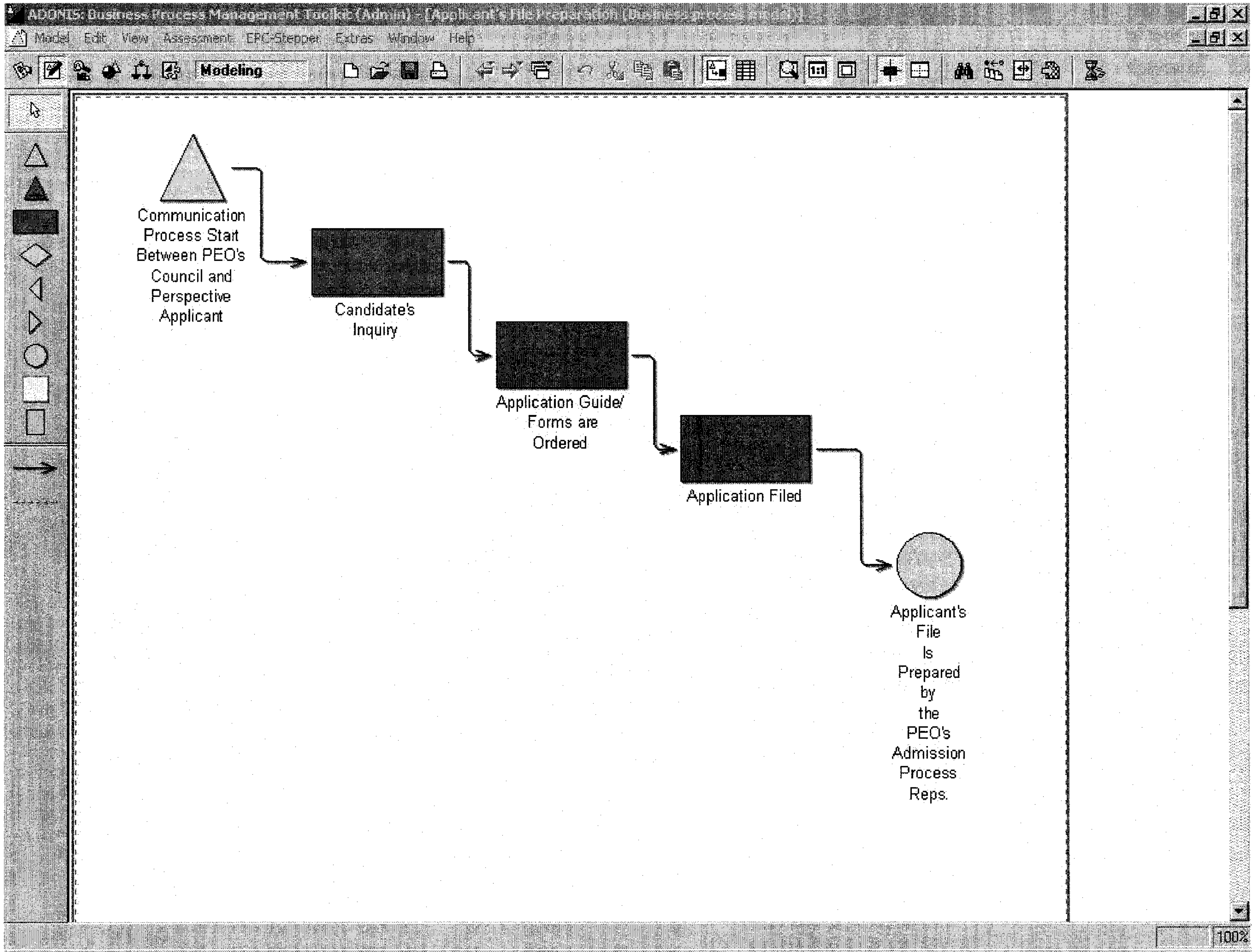
IDS SCHEER	Model objects in the modeled sequence	ARIS 6 Collaborative Suite

APPENDIX C

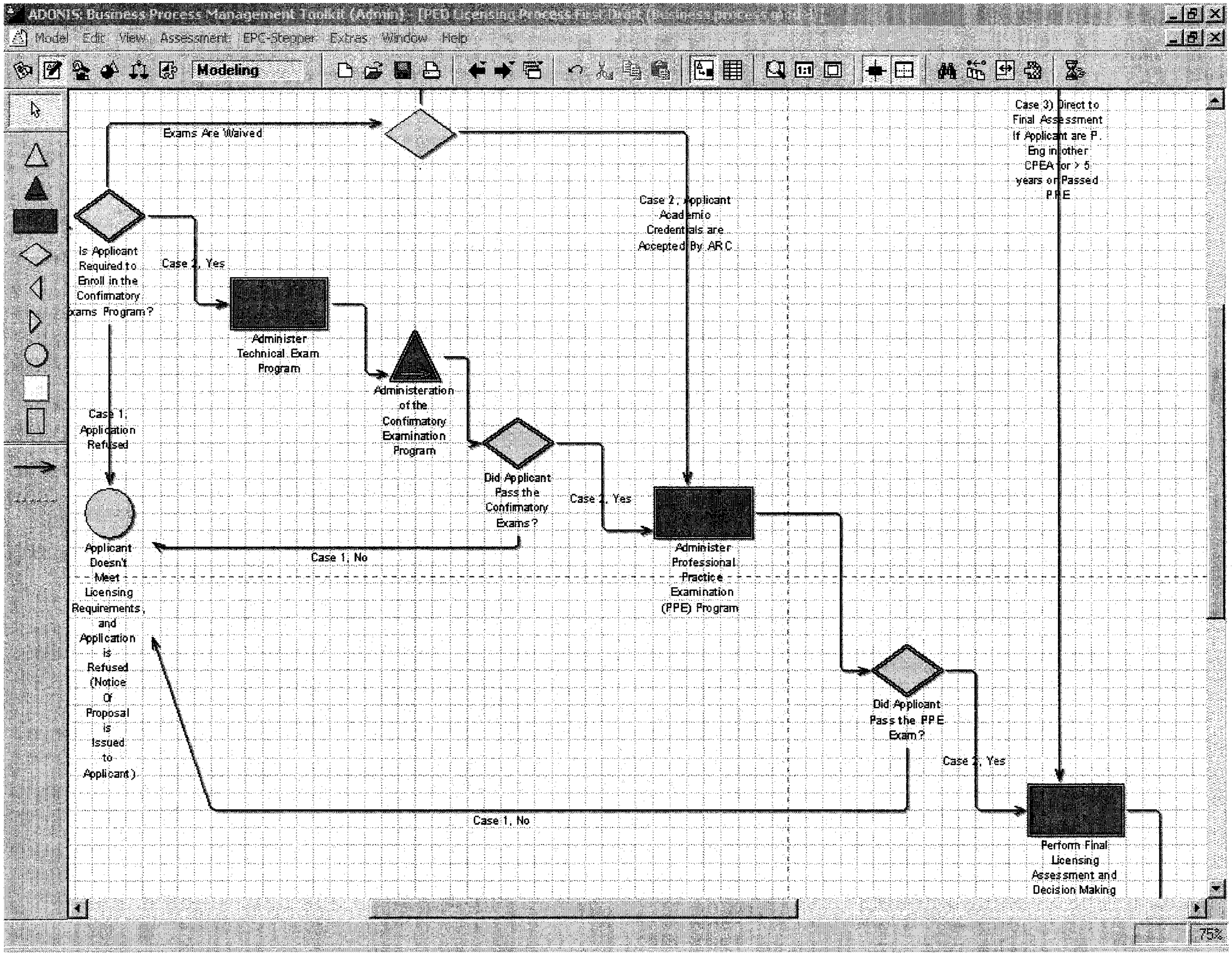
IMPLEMENTING THE ADONIS BUSINESS PROCESS MANAGEMENT TOOL KIT FOR MODELLING THE ONTARIO'S PROFESSIONAL ENGINEERS COUNCIL LICENSING PROCEDURE



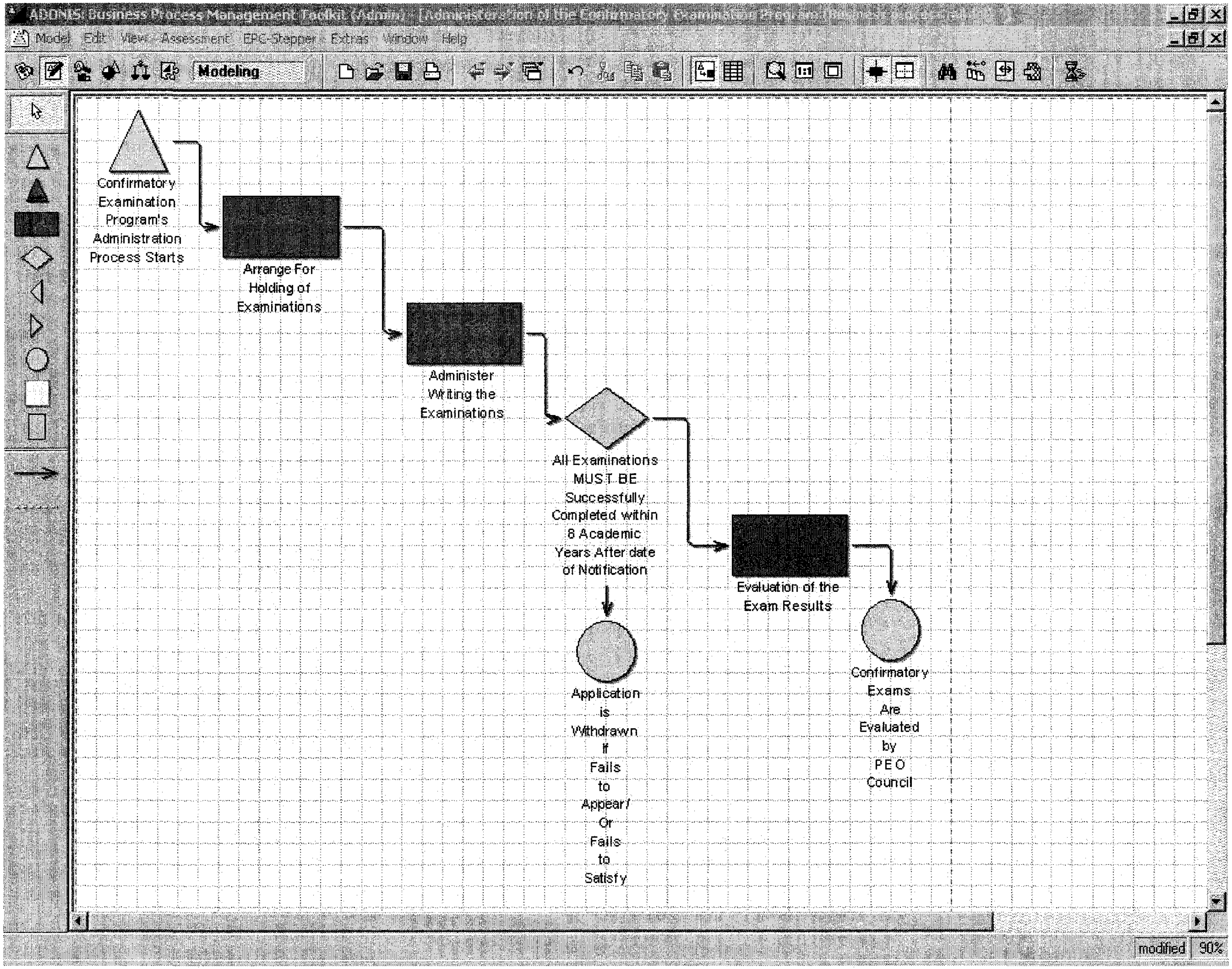
The ADONIS Standard Business Processes Model of The Professional Engineers Council Licensing Procedure



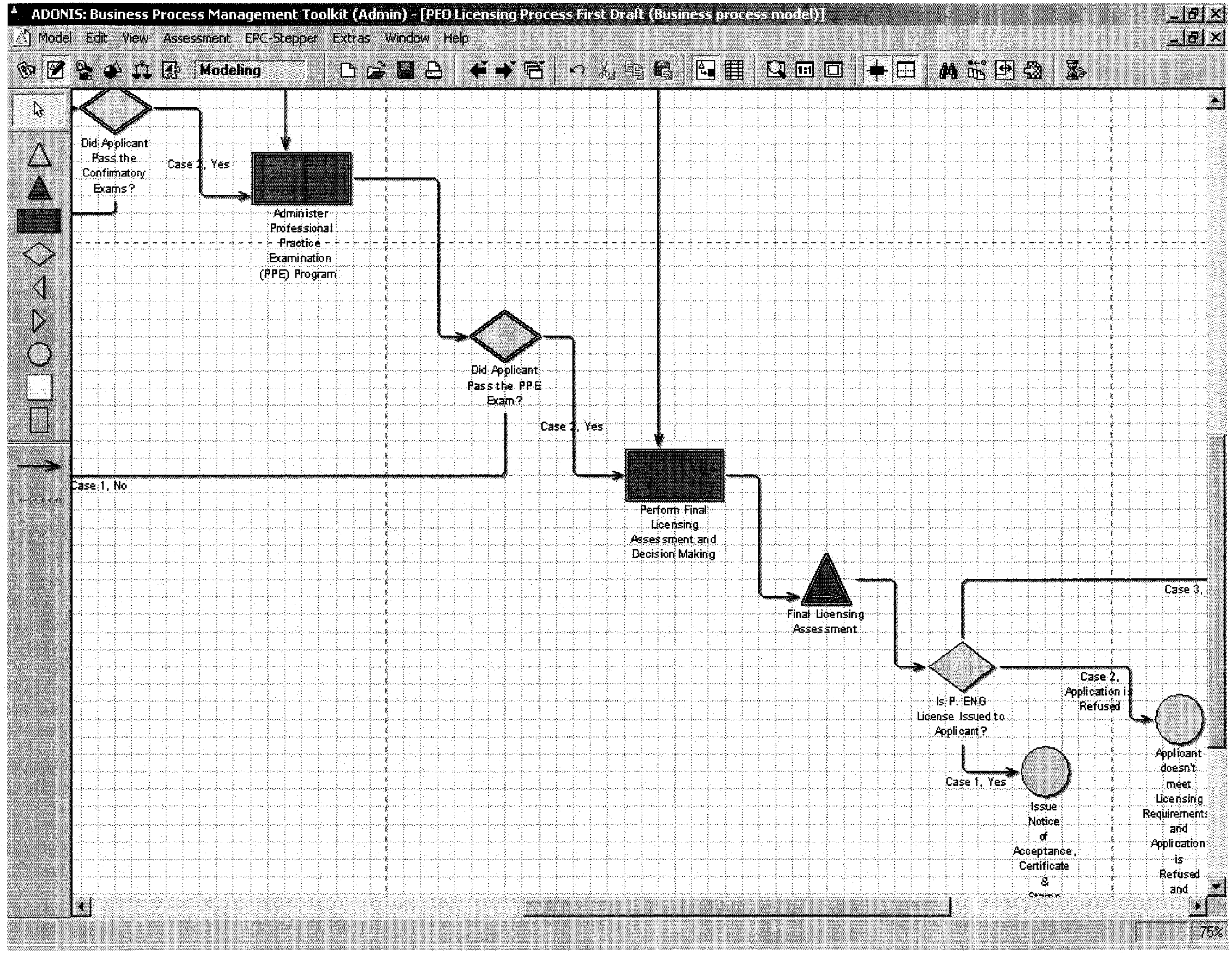
Continue The ADONIS Standard Business Processes Model of
The Professional Engineers Council Licensing Procedure



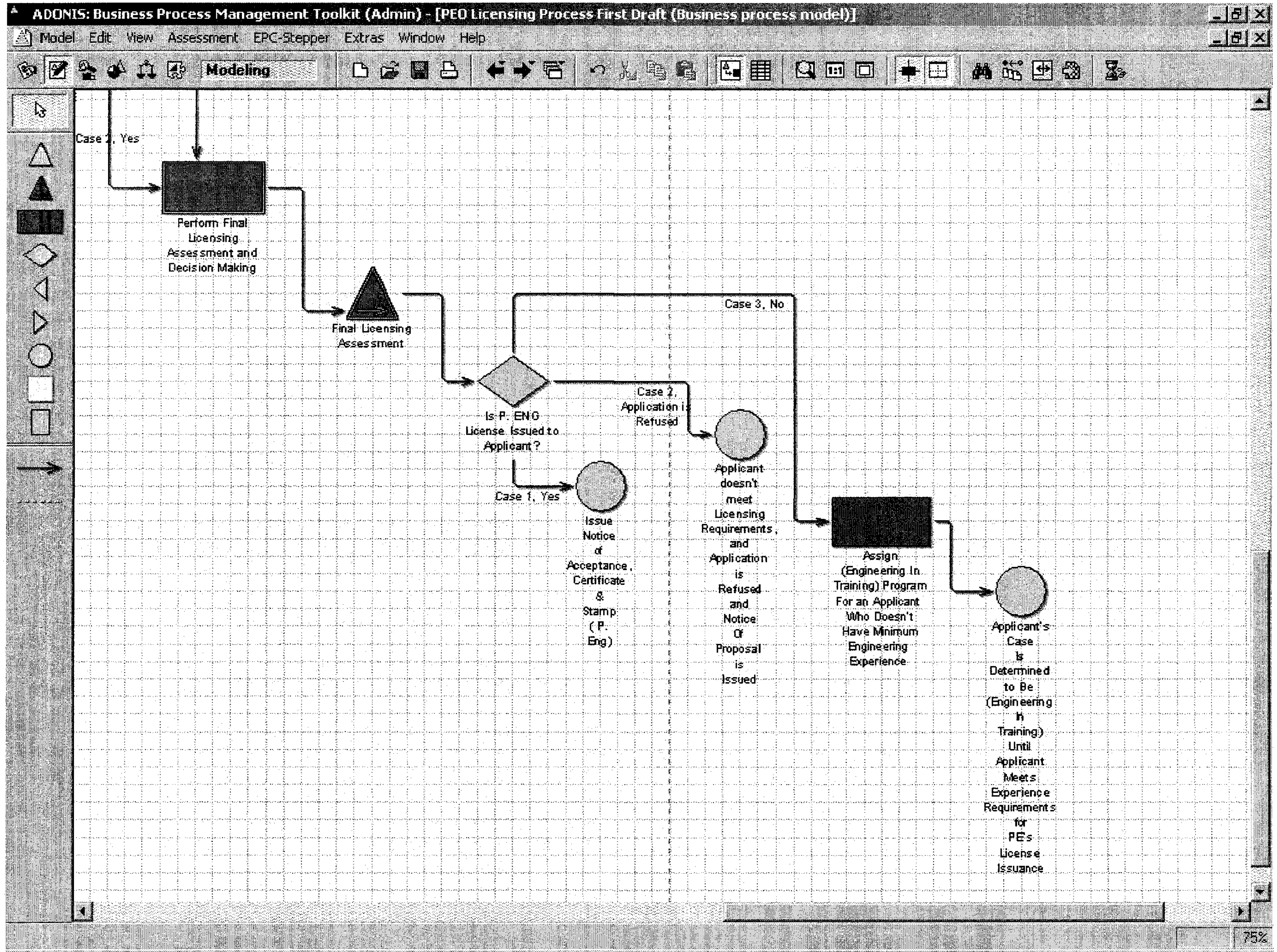
Continue The ADONIS Standard Business Processes Model of The Professional Engineers Council Licensing Procedure



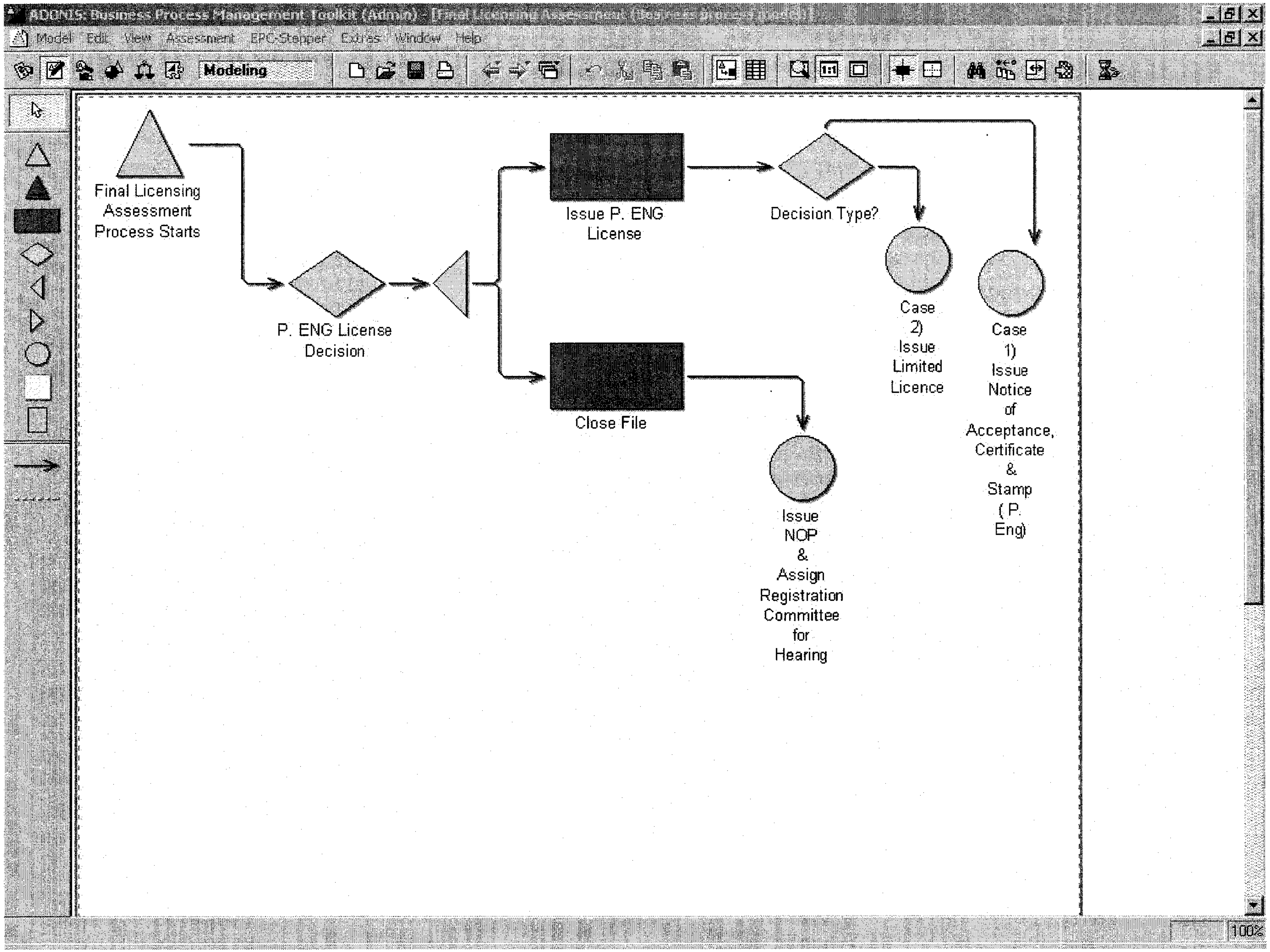
Continue The ADONIS Standard Business Processes Model of The Professional Engineers Council Licensing Procedure



Continue The ADONIS Standard Business Processes Model of
The Professional Engineers Council Licensing Procedure



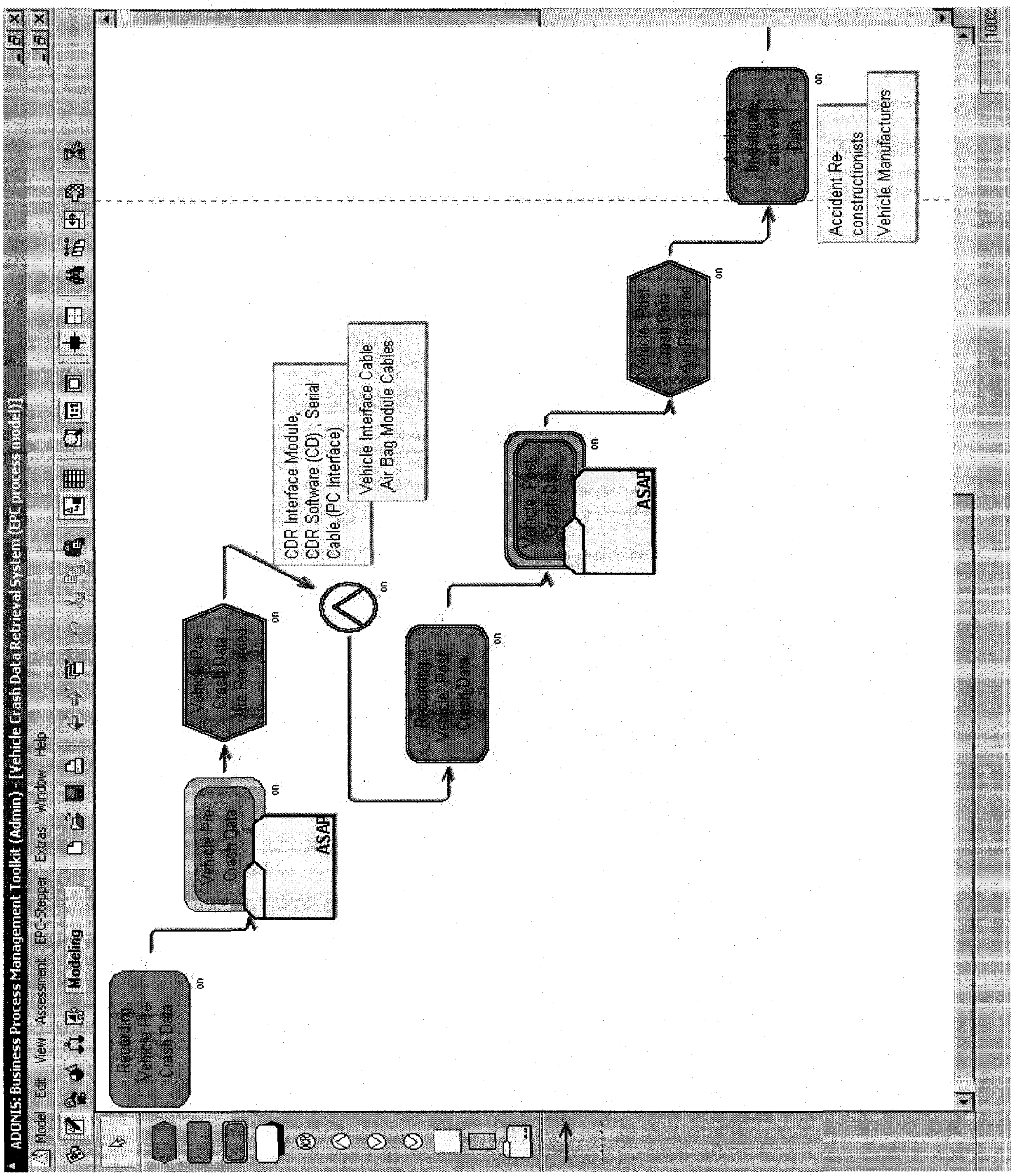
Continue The ADONIS Standard Business Processes Model of The Professional Engineers Council Licensing Procedure



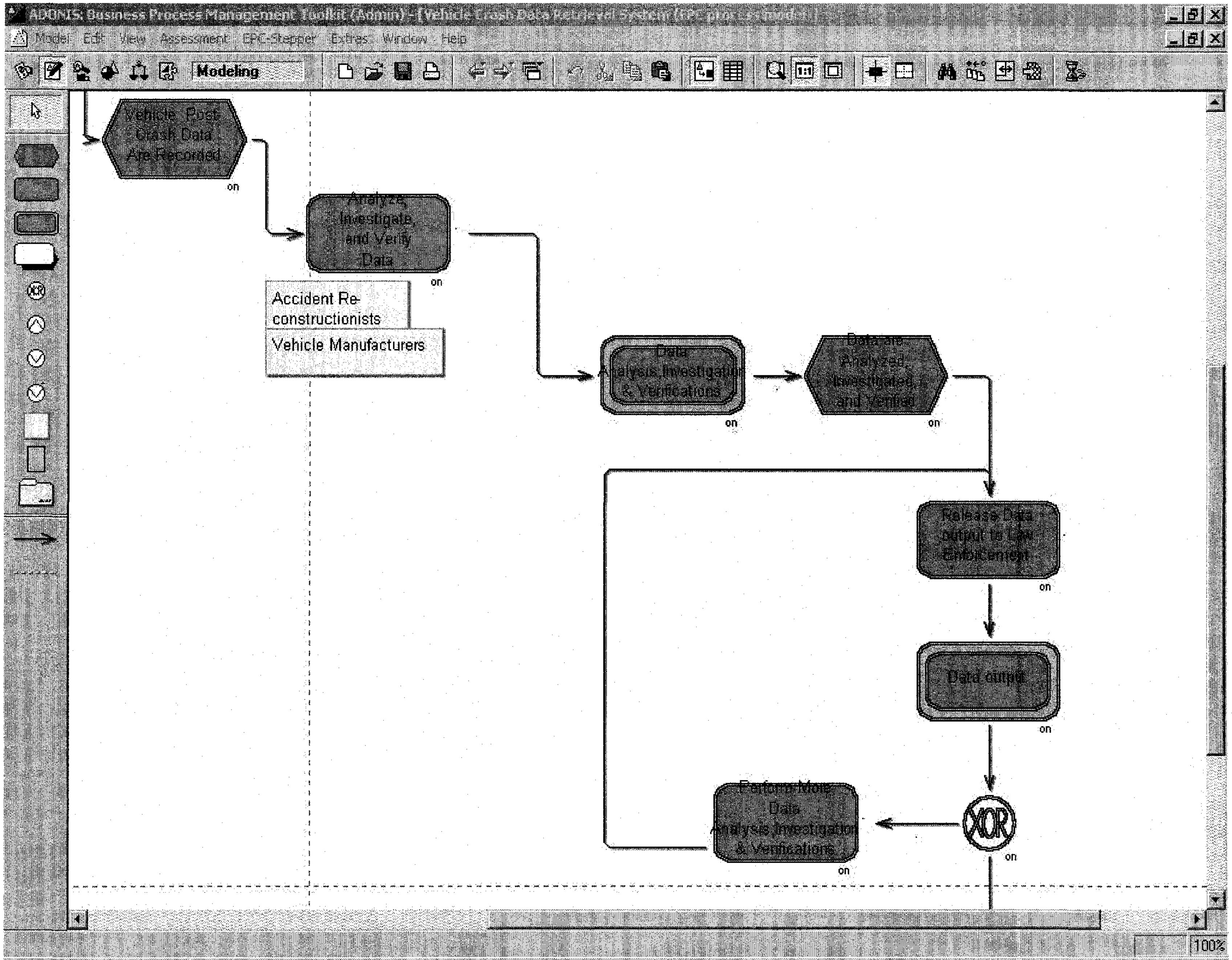
Continue The ADONIS Standard Business Processes Model of The Professional Engineers Council Licensing Procedure

APPENDIX D

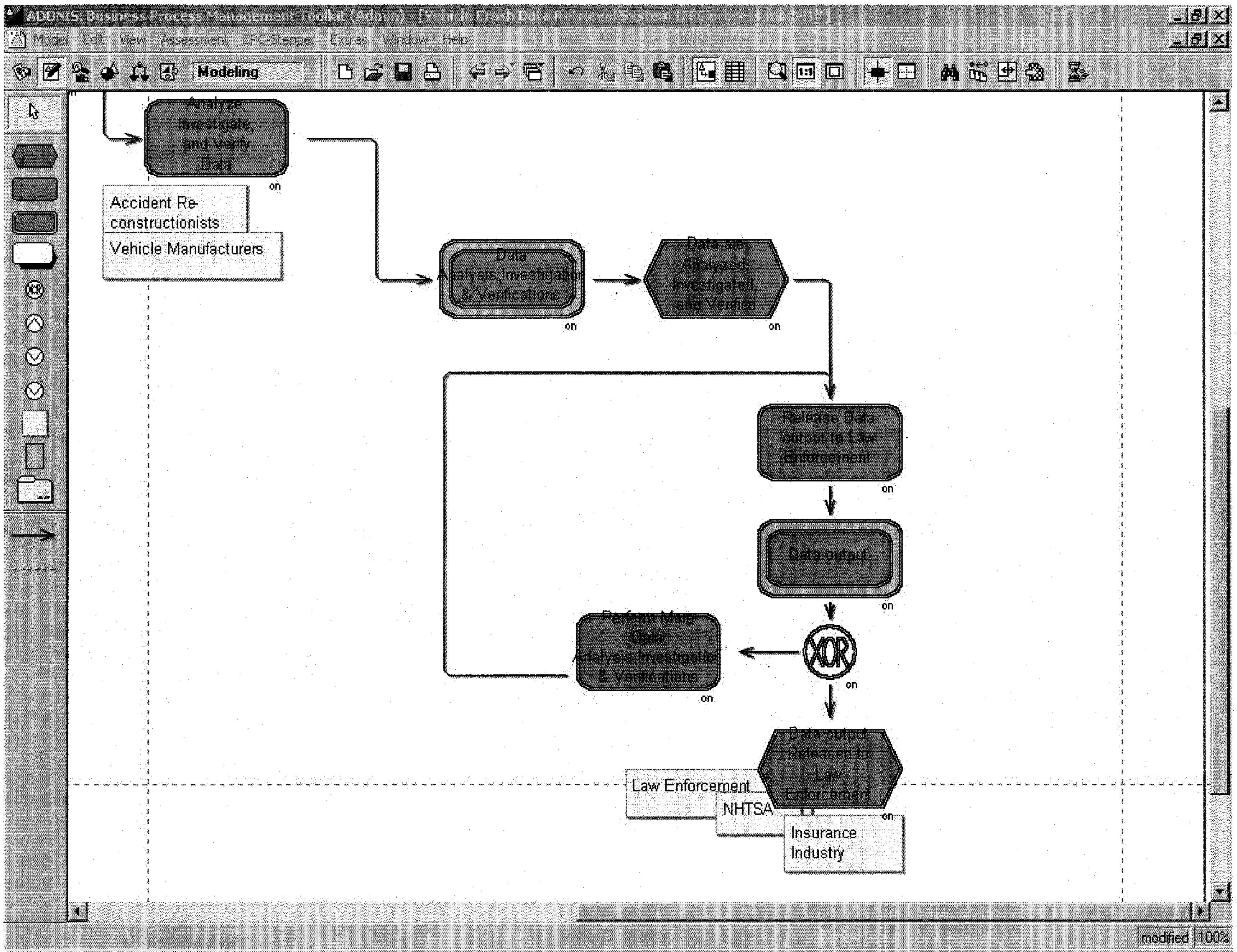
IMPLEMENTING THE ADONIS BUSINESS PROCESS MANAGEMENT TOOL KIT FOR MODELLING THE VEHICLE CRASH DATA RETRIEVAL SYSTEM



The ADONIS Standard Processes Model For Modeling The Vehicle Crash Data Retrieval System



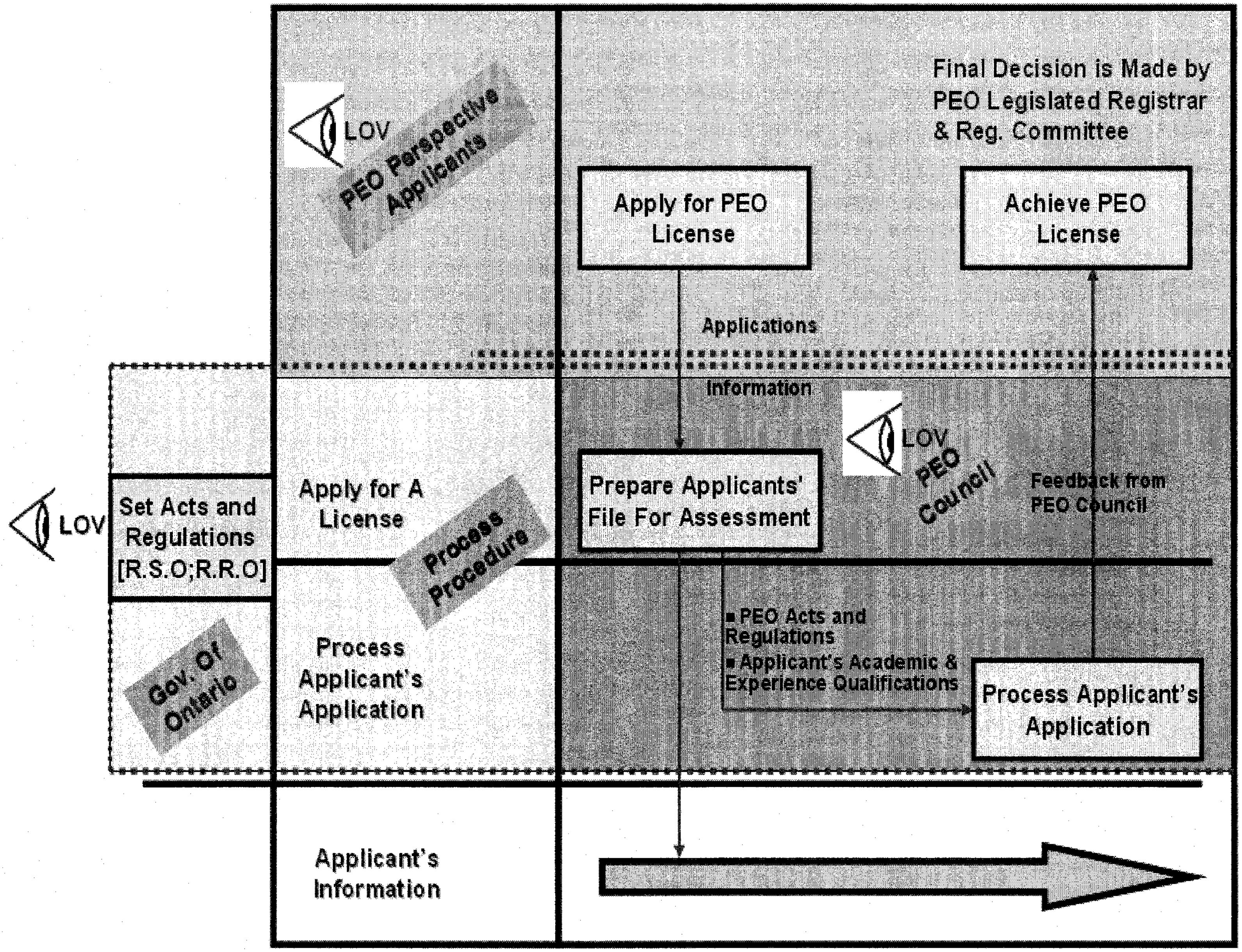
Continue The ADONIS Standard Processes Model For Modeling The Vehicle Crash Data Retrieval System



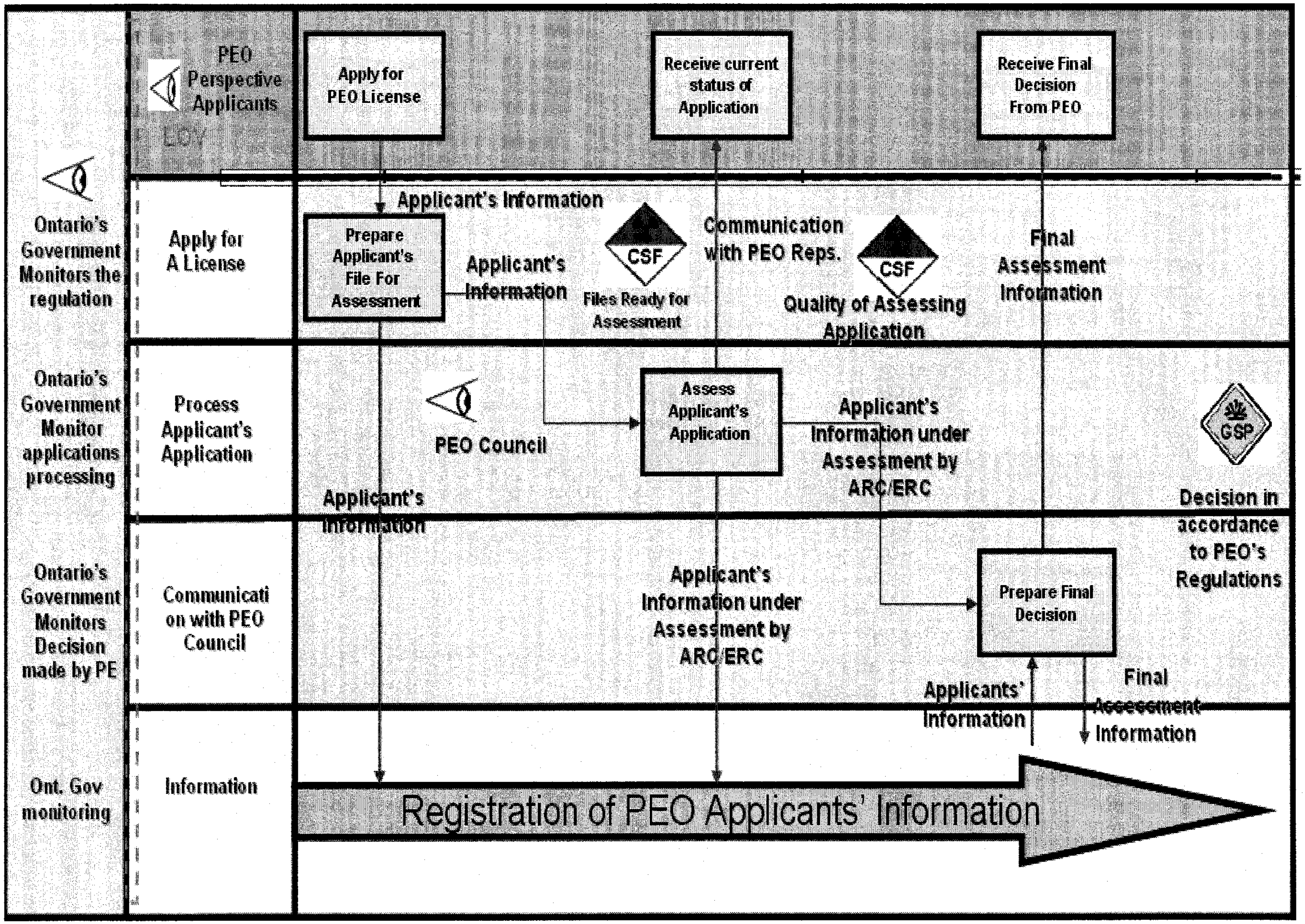
Continue The ADONIS Standard Processes Model For Modeling The Vehicle Crash Data Retrieval System

APPENDIX E

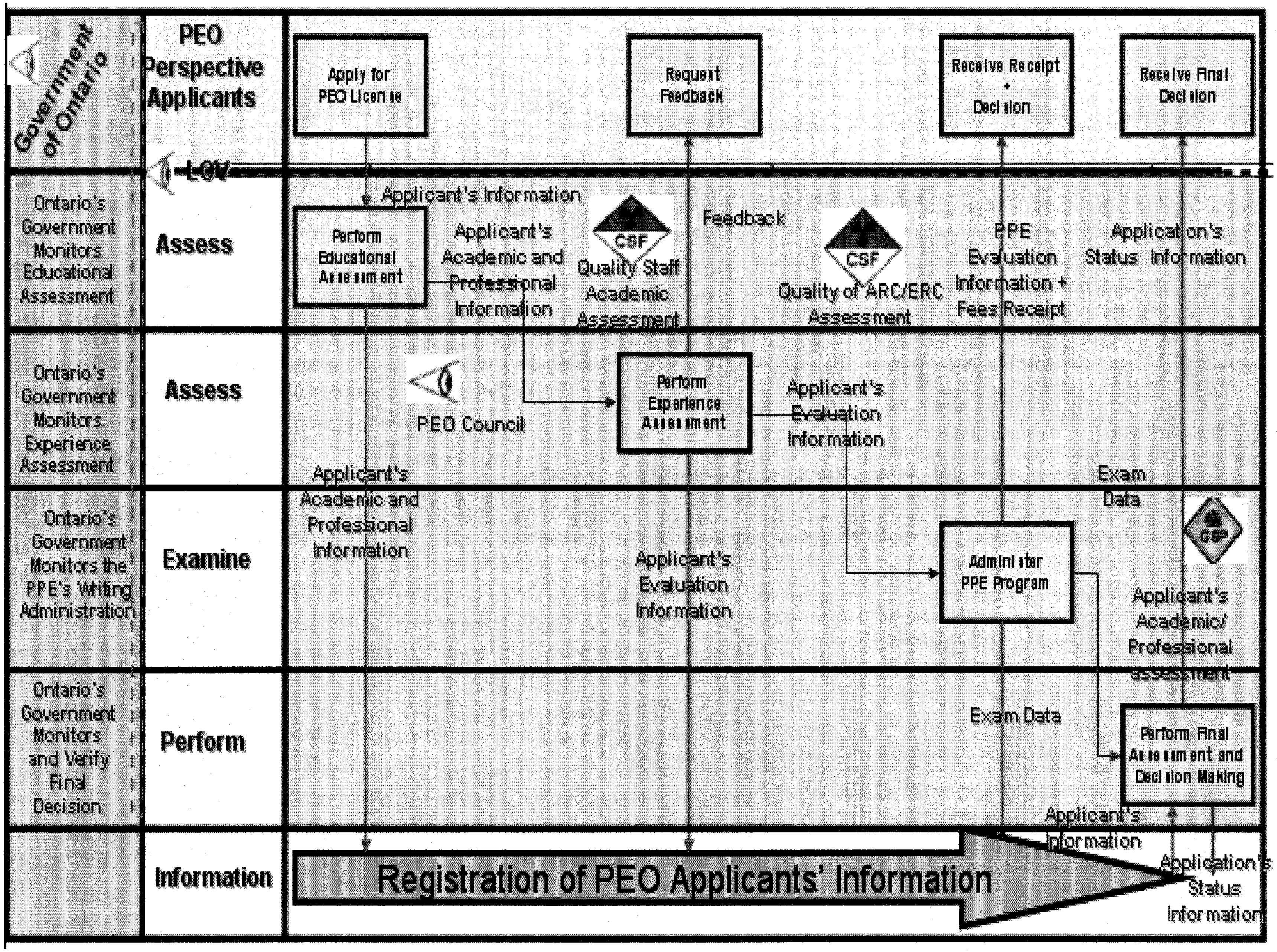
EXTENDED APPROACH OF THE LINE OF VISIBILITY OF THE PROFESSIONAL ENGINEERS COUNCIL LICENSING PROCEDURE MODEL



Extended GENERAL LLOV Chart For Modeling the PEO Licensing Processes Procedure



Extended Detailed LLOV Chart For
Modeling the PEO Acts and Regulation



Selected Detailed LLOV Chart For Modeling the Legislated PEO's Licensing Process Procedure

APPENDIX F

LINE OF VISIBILITY IN ADONIS INSTALLATION PROCEDURE

****

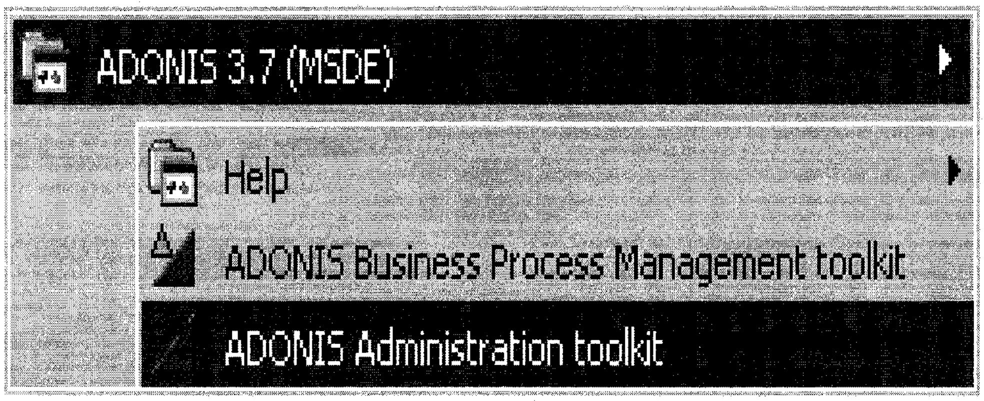
BOC ITC GmbH
Bäckerstrasse 5/3
A-1010 Wien
Tel.: +43-1-513 27 36-63
Fax: +43-1-513 27 36-5
email: silke.palkovits@boc-eu.com
www.boc-eu.com

****

Checklist for the first steps in ADONIS®

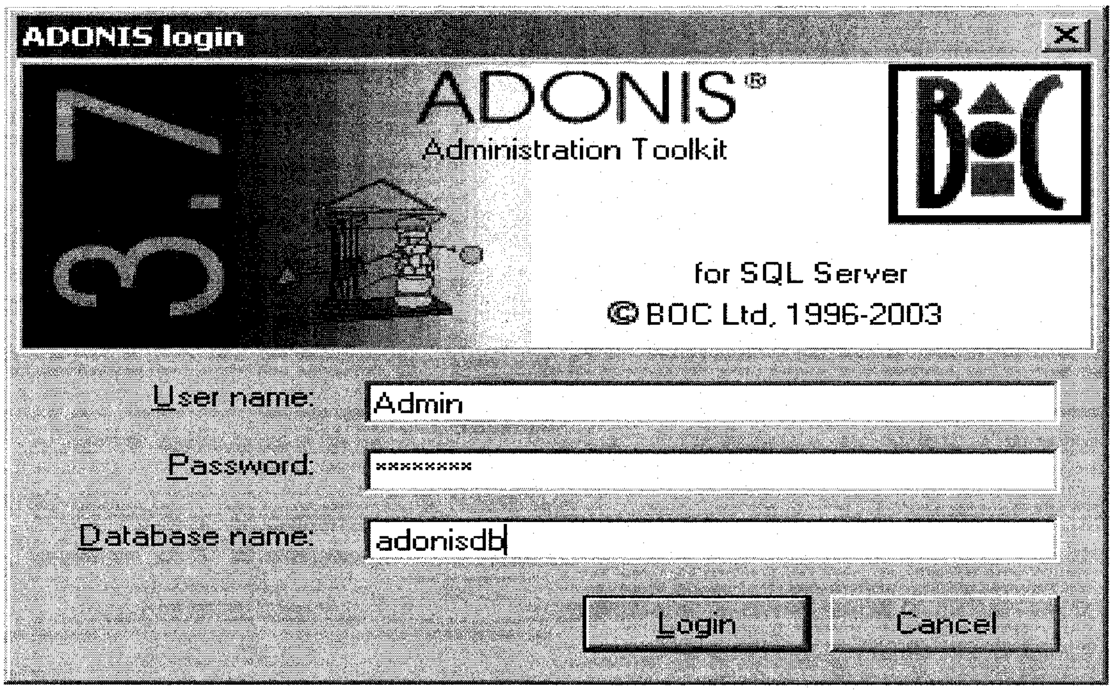
The following steps should enable you to change the default settings of ADONIS® according to customer's needs. These first steps, for example creating new users in ADONIS® or to create some additional folders to store your models in are described below.

1. **Choose The Administration Toolkit**



The ADONIS Administration Toolkit is the part of ADONIS in which the settings of the ADONIS installation are administered. The access rights of different ADONIS users are adjusted in this part of the software and will be checked when the user logs on into the Business Process Management Toolkit. The Administration Toolkit gives also the possibility to install detailed access rights to particular model groups or folders where models are stored. For example, there are two different folders; one belongs to the IT department.

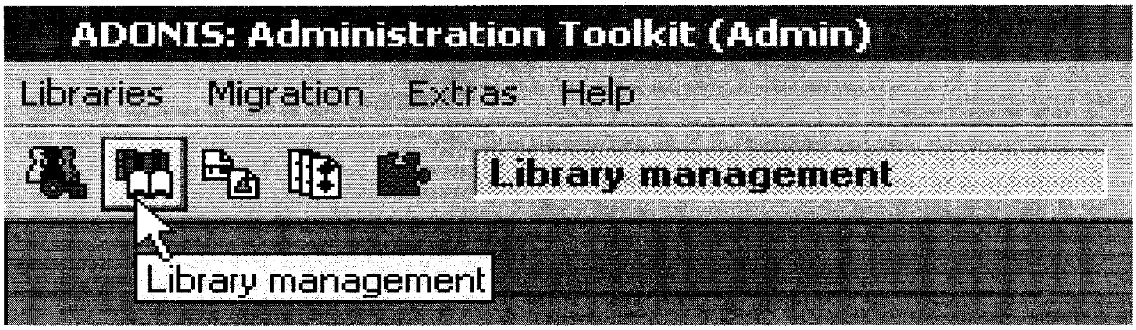
2. **Logon With The Standard User "Admin"**



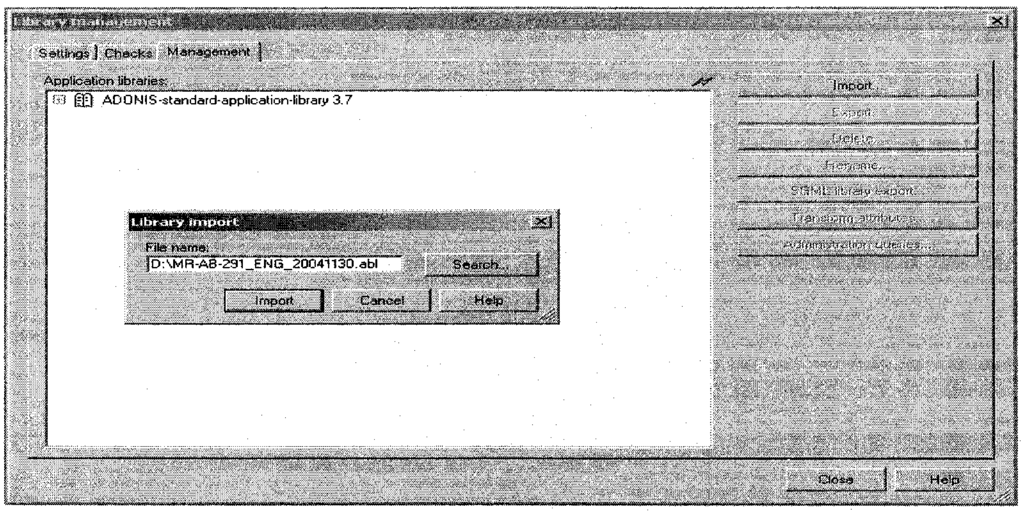
The standard user of ADONIS is the "Admin" user. This user cannot be deleted. For the first logon into the Administration Toolkit, the password "password" is used. The password of the "Admin" user can be changed after the first logon and the default database name is "adonisdb". If the database name has been changed during the installation procedure, this new database name has to be used when logging on.

3. **Switch To The "Library Management"**

The Administration Toolkit got three components including the user management, the library management, and the model management. For setting up the MR Method second component, the library management and the menu Management has to be chosen.



When pressing the "import the button on the appearing window", it is possible to search in the network for the MR Method – MR application library.

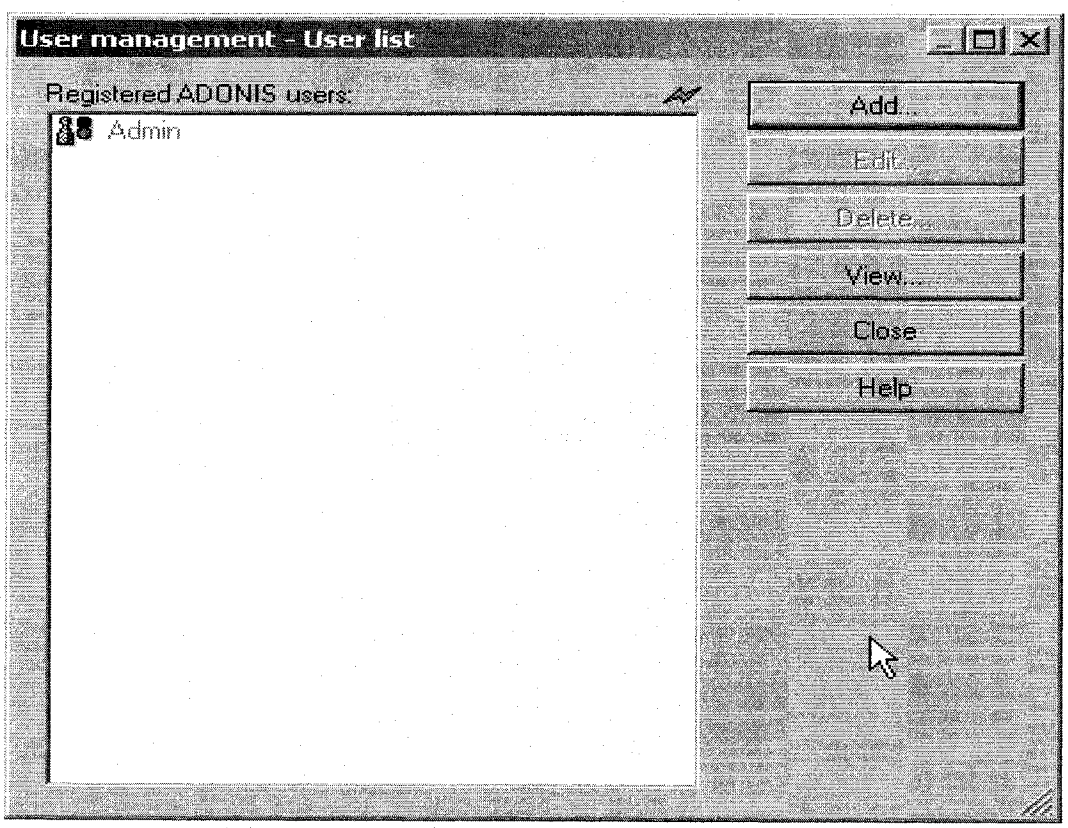


During the installation procedure, the default model group or folder "Models" can be created. The respective question needs to be answered with "Yes". The import of the MR Method is confirmed with a success message.

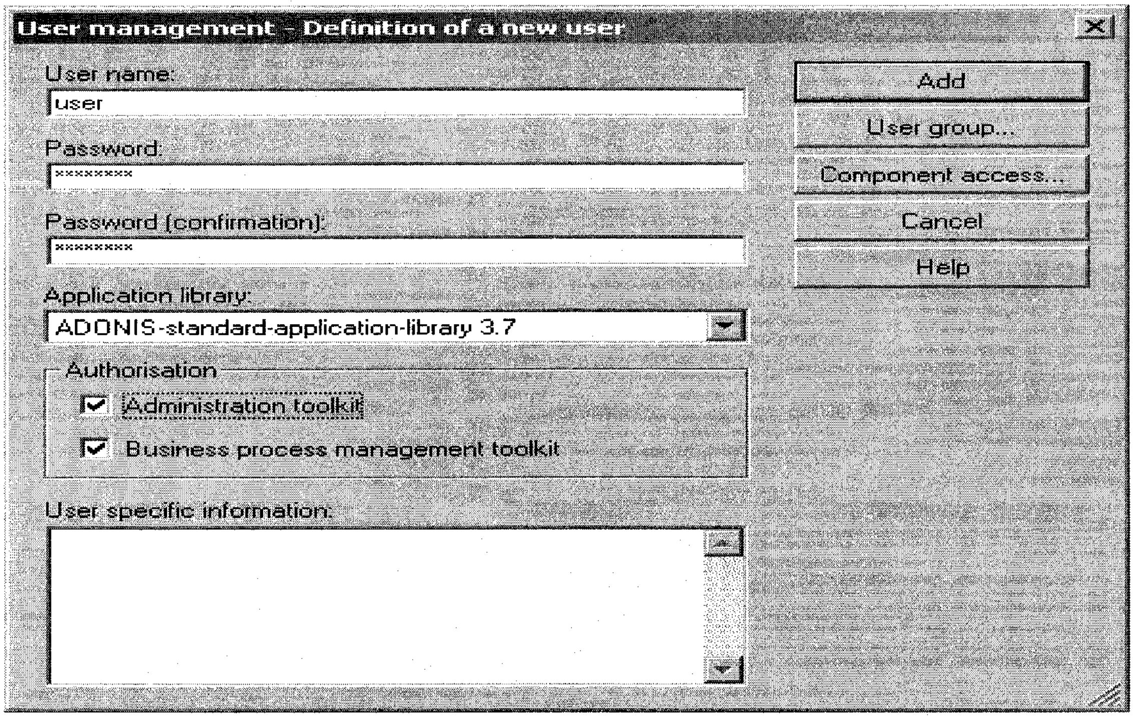
4. Switch To The "User Management"

To perform the next steps, it is necessary to switch to the first component the "user management". To create a new user from the menu, user and the submenu button, user list has to be chosen.

After pressing the button "user list", a dialog will be offered where users can be added. In the dialog, the only user is the "Admin user" which is already logged on and was pre-defined. Add new users by clicking the "add button".



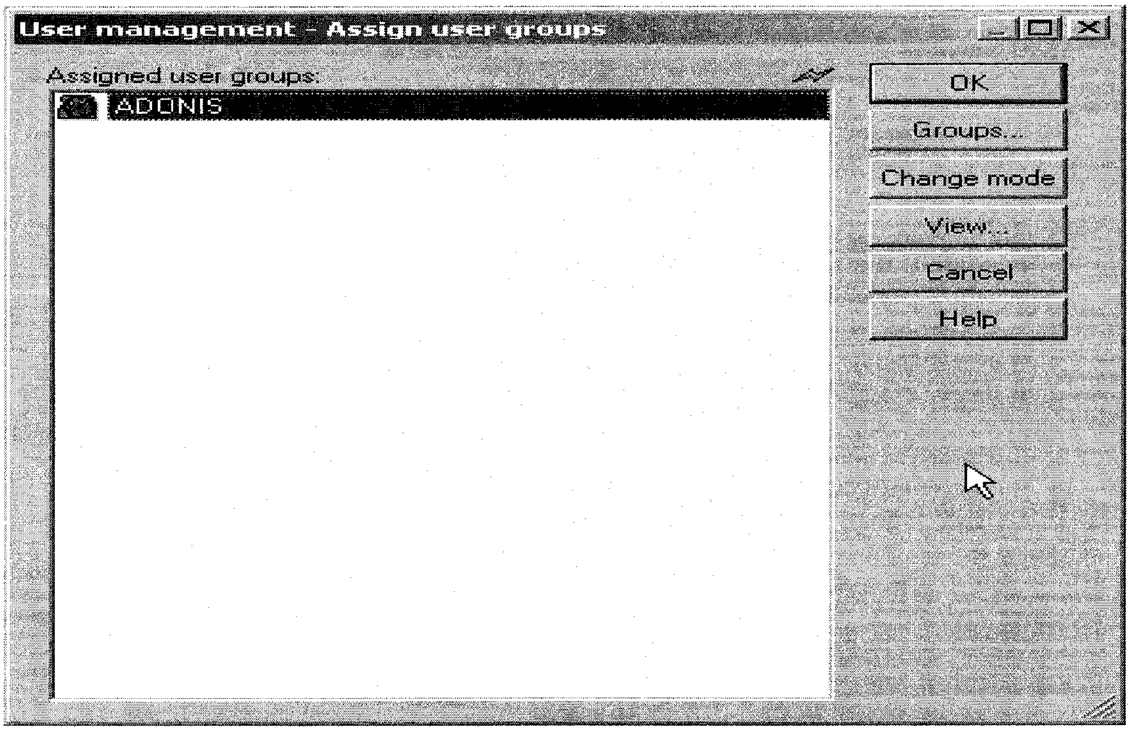
5. Add New Users



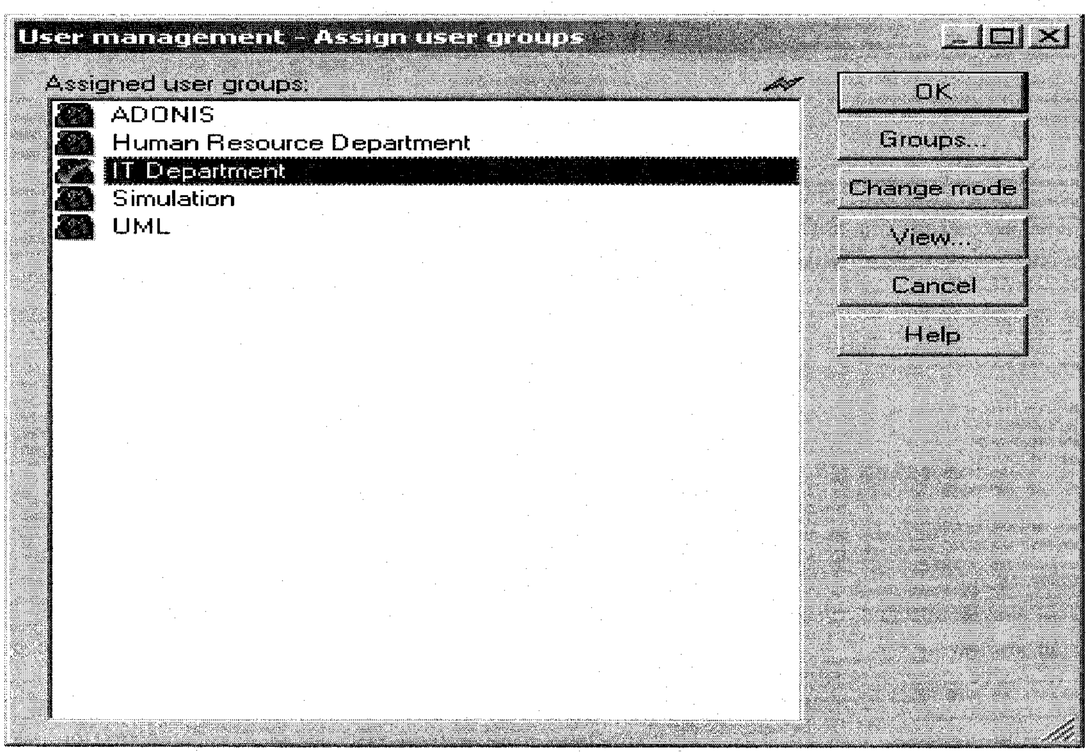
For creating a new user, the new user name has to be typed in and a corresponsive password that needs to be confirmed. The user must be assigned to an application library, which is a particular configuration of ADONIS. Depending on which method the newly created user should use when working with ADONIS, the user needs to be assigned to the "ADONIS-standard-application-library 3.7" or to the "ADONIS-Munich Re-Insurance-V2.91 Application library (2004-11-30)". When creating a new user, it has to be decided if he or she should be able to logon to the Administration Toolkit as well.

6. Assign A New User To A User Group

Each user must be assigned to a user group where access rights to model groups or folders containing different models are stored are administered. To add the newly created user to a user group, the button "user group" in the dialog window of point 5 has to be pressed.



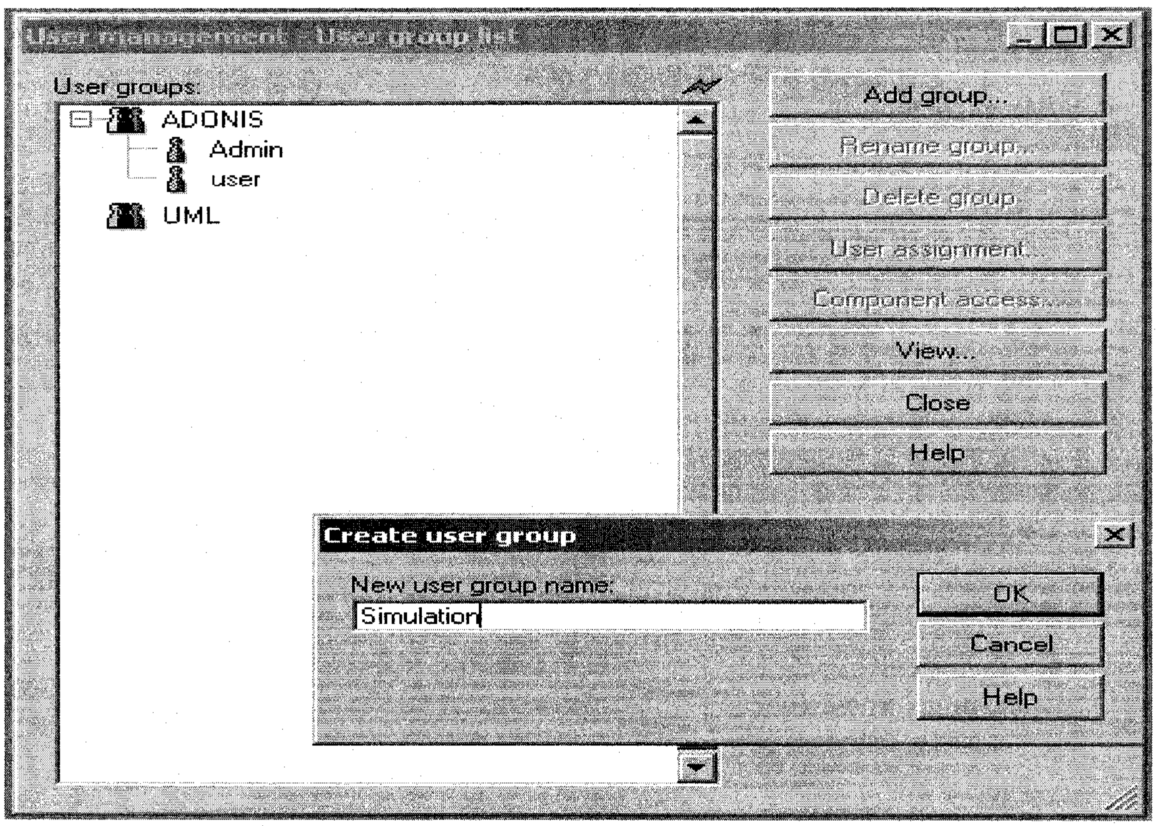
It is possible to assign the new user to the default user group „ADONIS“ or to a separate user group. To add a new user group the „Groups...“ button has to be clicked.



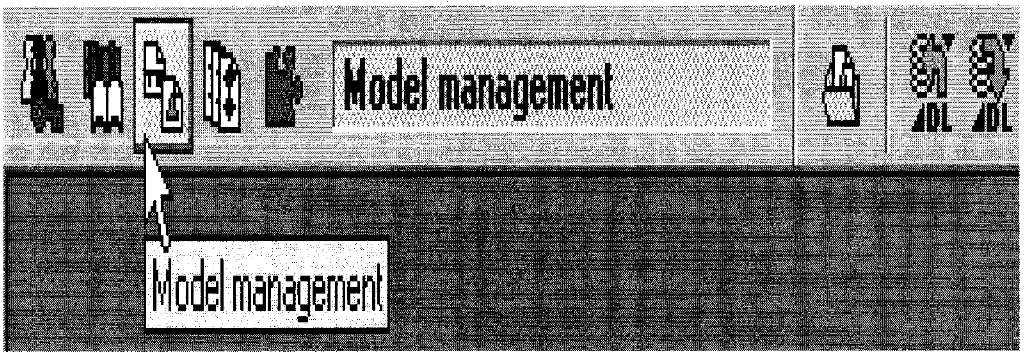
To assign a user to a user group, the "change mode" button has to be pressed and the red circle will change to a green check mark. All changes have to be confirmed with the "ok" or add button to leave the dialog for adding new users. The "cancel" button has to be pressed.

6.1 Create User Groups Independently From Creating Users

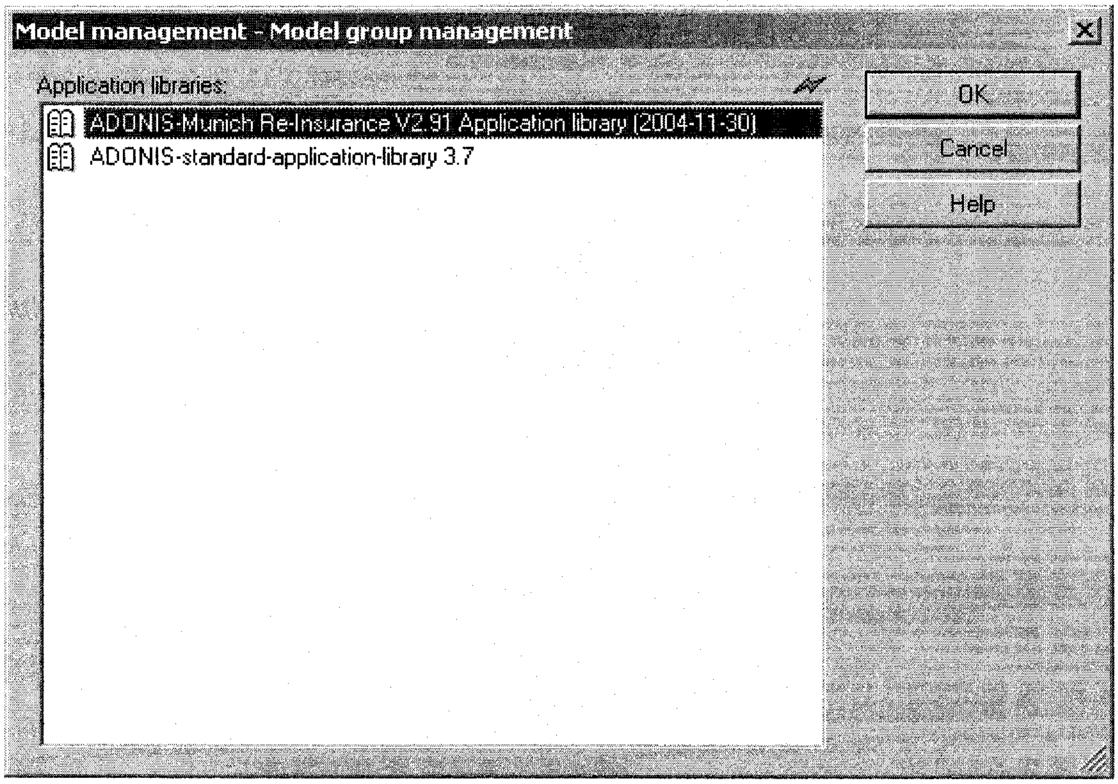
It is possible to create user groups and users one after the other as well. To create user groups, switch to the "user management" and chose the menu "user group list". In the dialog, click "add group" and add the required user groups. For example, "UML", the respective users will be assigned according to the guidelines described in chapter 6.



7. Assign User Groups To Model Groups In The "Model Management" Component"

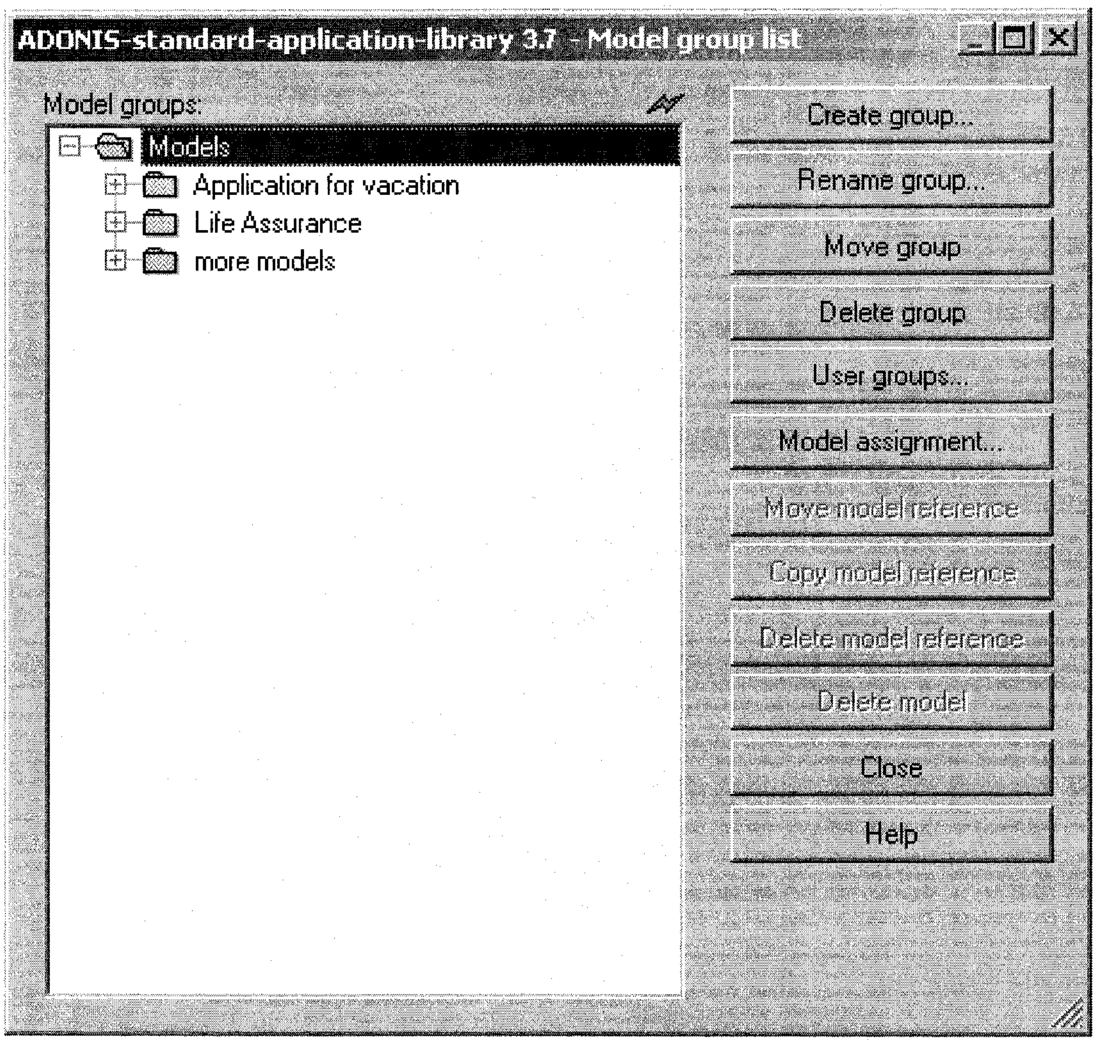


To switch to the "model management" component, press the third component icon then the menu button "models" and "model group management. To set up the model, group structure and access rights one of these methods need to be chosen. After that, you have to confirm with the "ok" button.



8. Create new model groups / folders

When working with ADONIS and creating models, it is necessary to assign the models to a particular model group or folders. These model groups are created in the "model management" component. Each model group have several sub-model groups; basically it is the same concept like the Windows directory structure in the file explorer.

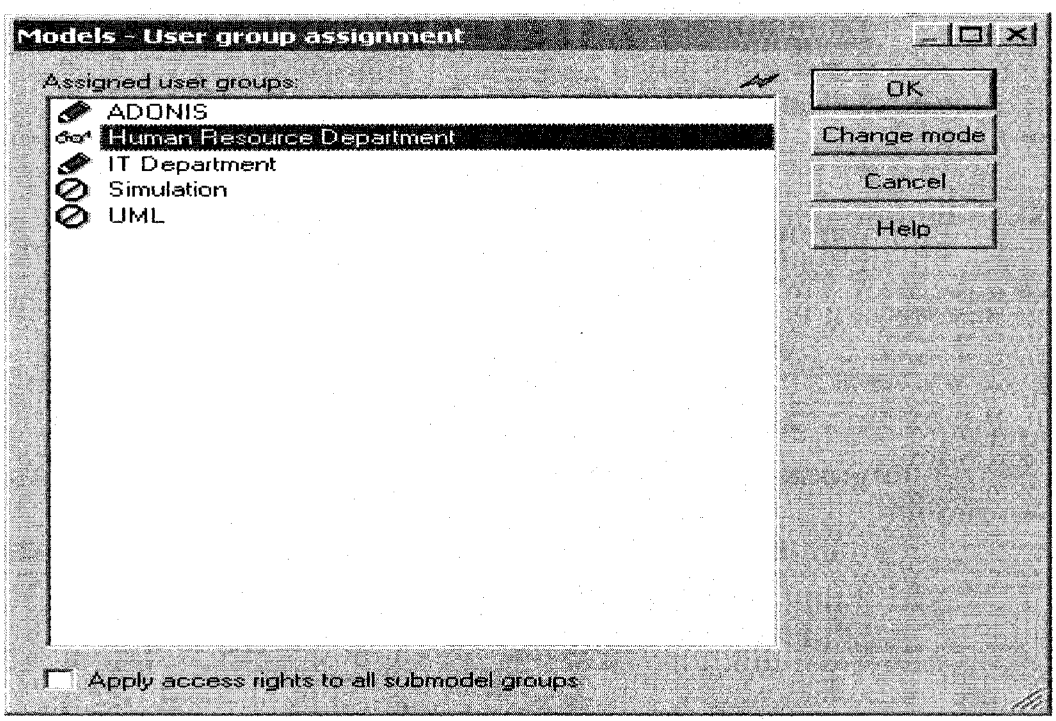


A new model group can be created by clicking on the "create group" button. Whenever a model group is selected, the "create group" button is clicked. A sub model group will be created after. Whenever a particular model group is not selected, a "main model group" will be created that has the same hierarchy as the "model group" in the screen shot.

9. **Assign user groups to model groups / folders**

As already stated, users are assigned to user groups. User groups are assigned to model groups. User groups are assigned to model groups by selecting the respective model group and pressing the "User groups" button. A dialog will pop up showing all the different user group which exists existing in ADONIS. Using the "changing mode" button, the access rights can be adjusted for the particular model groups respectively user group. There are three different levels of user rights:

- No access at all – this is the red circle,;
- Read only – theses are the glasses; or
- Write access – this is the pencil.



Confirm the changes with the "ok" button. With these steps, the first settings are defined. The newly created users should be able to access the ADONIS Business Process Management Toolkit with their user names and their passwords [BOC ITC GmbH, 2004].

VITA AUCTORIS

Anas Kazaal was born in 1976 in Hama, Syria. He graduated from AL-Ghaznawi High School in 1994. From there he went on to the King Fahd University of Petroleum and Minerals where he obtained a B. Sc. degree in Systems Engineering in 1999. He has obtained an M. Eng. degree in Engineering Management from the University of Ottawa in 2002. He is currently a candidate for the Master's degree in Industrial Engineering at the University of Windsor and hopes to graduate in Winter 2005.